GUIDE BOOK No. 9

TRANSCONTINENTAL EXCURSION C 2

TORONTO TO VICTORIA AND RETURN

VIA CANADIAN PACIFIC

GRAND TRUNK PACIFIC AND

NATIONAL TRANSCONTINENTAL

RAILWAYS

GEOLOGICAL SURVEY
DEPARTMENT OF MINES
OTTAWA
1913

F. C. Dyer.

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Transcontinental Excursion C 2

Toronto to Victoria and return via Canadian Pacific, Grand Trunk Pacific and National Transcontinental Railways

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SUDBURY, ONTARIO, TO DUNMORE, ALBERTA.*

BY

W. H. COLLINS AND CHARLES CAMSELL.

From Sudbury westward to Murray mine the main line of the Canadian Pacific railway ascends among hills of granite and highly folded Huronian greywacke, arkose, quartzite and greenstone to the southern margin of the great boat-shaped intrusive body with which the nickel deposits of this district are associated. The southern rim of the intrusive is crossed between Murray mine and Azilda, the gossan and dark basic rocks of the outer edge passing insensibly into flesh-coloured micropegmatite as the inner edge just west of Azilda is approached. From Azilda almost to Onaping the railway is within the elliptical area enclosed by the rim of the nickel eruptive and for practically all of this distance it traverses a flat plain of stratified clay formed in a part of old Lake Algonquin. The sandstone member of the Upper Huronian series which occupies the basin of the nickel eruptive and underlies this lacustrine clay, outcrops in low, dome-shaped hills at Chelmsford and Larchwood. The hilly rim of the nickel eruptive is again crossed, from the acid to the basic edge, in the neighbourhood of Onaping and Windy lake and a great monotonous region of Laurentian granite-gneisses and Keewatin schists is entered, which continues for the next 450 miles (725 km.).

The granites and gneisses of this region are characterized on the whole by an abundance of lime-soda feldspars and range in composition from granite to granodiorite, less frequently to syenite or diorite. But between Peninsula and Middleton the railway crosses a plutonic mass of nepheline and other alkali-syenites, 15 miles (24 km.) in diameter. This is the only known area of alkaline rocks in the region between Sudbury and Port Arthur. It is described in greater detail in the guide book of Excursion C 1.

As seen along the railway the alkali syenite mass appears to possess a basic margin. Its eastern edge consists of dark red augite syenite. This gives places more or less gradationally to pale feldspathic syenites in the centre of the area near Coldwell, and from Coldwell to Middleton the

*For a more detailed description of this portion of the Excursion see Guide Book No. 8, Part I.

same transition occurs in reverse order, the western margin consisting of dark red syenites like those near Peninsula. A great variety of rock types, ranging from nepheline syenite to olivine gabbro, is present but they are all evidently the result of one act of plutonic intrusion. The latest investigators regard the order of consolidation to have been in general from the most basic to the most acid type, followed by a final intrusion of dykes of camptonite and allied materials.

The mass is intrusive into Keewatin schists and Laurentian granite-gneiss.

Lake Superior is in sight at intervals from Peninsula to Nipigon

The Keewatin and Laurentian rocks that reappear at Middleton continue to Gurney where they become overlain by flat-lying Keweenawan sediments and diabase sills intrusive into these sediments. The first of these formations seen is a bright red sandy dolomite, which contains disseminated patches of gypsum, and other evidences of arid climatic conditions at the time of its deposition.

The intrusive diabase sills appear near Kama, giving a first impression of the precipitous mesa-like topography which they produce in greatest prefection near Fort William. The shore deposits of old Lake Algonquin are also exposed in cuttings near Nipigon.

Between Nipigon and Port Arthur, Animikie (Upper Huronian) and Lower Huronian rocks also appear. These as well as the other Pre-Cambrian series are particularly well exposed near Loon. In this locality which is described more fully in the guide-book of Excursion C1, the Keewatin volcanic rocks and Lower Huronian conglomerate, greywacke and greenstone have been intruded by Laurentian granitic batholiths and so folded and altered to schists that a separation of the two groups is almost impossible. The flat-lying and little metamorphosed Animikie sediments lie unconformably upon a greatly eroded surface of these older rocks. They consist, from top to bottom, of (1) black slate, (2) upper iron formation, (3) slate, (4) thin-bedded, impure limestone, (5) iron formation, and (6) quartz conglomerate. The lower iron formation, is, perhaps, of greatest interest for it exhibits a variety of stages in the development of iron ore from the lean iron formation. Keweenawan conglomerate, sandstone and impure limestone, all deposited in shallow water, lie un-

conformably upon the Animikie. These formations as well as the older ones, are intruded by dykes and sills of diabase.

The relations of these sills to the Animikie sediments is particularly well shown in Current River park, Port Arthur, where a flood, caused by the bursting of a dam, has swept the rock floor quite free of soil. This rock floor consists largely of the upper surface of a diabase sill upon which vestiges of the original covering of black slate still adhere. Slight contact metamorphic changes are observable in the slate, and there are local anorthosite segregations a few feet in diameter in the diabase due to aggregation of labradorite phenocrysts.

The Port Arthur district contains a number of silver mines, including the famous Silver Islet mine, which bear considerable resemblance to those at Cobalt. The deposits are fissure veins carrying native silver, native bismuth, and various arsenides, antimonides, sulph-arsenides, etc., of silver, cobalt and nickel. Like the Cobalt deposits also, they are closely associated with the intrusive diabase sills. The Port Arthur district is described at greater length in the guide-book of Excursion C1.

Between Fort William and Summit, a distance of 18 miles (29·0 km.) the railway traverses a flat delta plain but the characteristic flat-topped hills of this locality appear in the distance to the south. These, of which mount McKay is perhaps the best example, consist of flat-lying easily eroded Animikie sediments protectively capped by remnants of the intrusive diabase sills.

These formations thin out and finally disappear near Summit beyond which lies another great region of Laurention gneisses and Keewatin schists. This region, extending for 340 miles (547 km.) to Darwin, is more heavily drift covered than that along Lake Superior but is not essentially different from it structurally or lithologically. The glaciated topography is more subdued and rocky lakes are more numerous. Excellent views of Eagle lake are obtained at Vermilion and of Lake of the Woods just west of Kenora. Gold is mined on Eagle lake, Lake of the Woods and at numerous other points in the Keewatin south of the railway. The stratified clay near Dryden, which was probably deposited in a small glacial lake, supports a scattered farming community and is used for brickmaking at Dryden.

Near Darwin the Pre-Cambrian shield disappears at a very low angle under the alluvial plain representing the bed of glacial Lake Agassiz. Between this station and Winnipeg the old lake bed gradually changes from a slightly rolling, heavily forested country to level, treeless prairie. The Ordovician limestone of the interior plains regions, which laps over the Pre-Cambrian shield from the west, is hidden beneath the Lake Agassiz silts and clays except near Tyndall and Garson where quarries may be seen at some distance from the railway.

Winnipeg is the gateway to the Great Plains of Western Canada. It is situated in the basin of glacial Lake Agassiz, an extinct lake which drained southward to the Mississippi, and deposited a thick sediment of silt and clay on a bed rock of Paleozoic limestone. The bed of Lake Agassiz has an elevation of 800 feet (243 m.) above sea level and forms the first prairie level of the Great Plains.

The western border of Lake Agassiz is the Manitoba escarpment which crosses the Canadian Pacific railway about Austin, where the surface of the plain rises to the second prairie level. This line of escarpment is coincident with the eastern edge of a wide band of Cretaceous which rests on the Paleozoic rocks and extends westward to the Rocky mountains.

The second prairie level has an average elevation of about 1600 feet above the sea and continues westward on the line of railway for about 280 miles (450 km.) to a point a short distance beyond Moosejaw. It is underlain by flat-lying Cretaceous rocks which, however, are so uniformly covered with a thick soil that outcrops of them are rarely exposed except in the river valleys.

The Missouri Coteau a few miles west of Moosejaw rises somewhat abruptly for about 500 feet (152 m.) from the second prairie level and forms the eastern boundary to the third prairie level which then stretches without any notable breaks to the foot of the Rocky mountains. To the south of the railway line between Moosejaw and Dunmore irregular flat-topped hills rise 1000 feet (304 m.) or more above the general level of the plain as remnants of a once higher plain since largely destroyed by erosion. These hills are built of undisturbed shales, sandstones and conglomerates of Oligocene age deposited after the period of crustal disturbance in which the Rocky mountains were elevated.

At Dunmore the route of Excursion C 2 leaves the main line of the Canadian Pacific railway to follow the branch line through the Crowsnest coal fields and the metal mining districts of Southern British Columbia, joining the main line again at Revelstoke, British Columbia.

DUNMORE TO BURMIS.

BY

D. B. Dowling.

INTRODUCTION.

The country traversed by the Canadian Pacific railway between Dunmore and Burmis is underlain by Cretaceous and possibly Tertiary rocks (St. Mary River series). The following are the geological formations in descending order:

St. Mary River series.
Pierre shales.
Belly River series.

From Dunmore to a point a little east of Lethbridge the country is underlain by the Belly River formation arched in the form of a flat anticline, the centre of which is probably near Bow island. The formation consists of shales and sandstones of brackish water deposition referred to Upper Cretaceous.

Succeeding the Belly River are the marine Pierre shales, the latest purely marine sediments of the plains. The beds have a slight dip to the west, which increases southwards, and are faulted with small displacements showing that the effect of the Laramide revolution extended as far east as Lethbridge.

The St. Mary River sandstone marks the top of the Cretaceous and may possibly be Tertiary. The attitude is that of a synclinal fold, the eastern limb being approximately at the crossing of the railway over the Old Man river, while the western limb lies between Pincher and Cowley at the crossing of the south fork of the Old Man river. Westwards from this point to Lundbreck successively lower beds are crossed, and at Lundbreck the rocks, which are of fresh and brackish water origin, are supposed to be the

equivalent of the Belly River series. The exposures occur along the banks of the Crowsnest river.

Westwards the dips vary greatly in direction and degree and show evidence of folding in the strata. Near Burmis a great fault occurs with a down throw to the east which brings the beds of the Lower Cretaceous in contact with the higher members. Coal seams occur in the Belly Rivers series.

ANNOTATED GUIDE.

Miles and Kilometres.	
0 m. 0 km.	**Dunmore.**—Altitude 2,398 ft. (729 m.). Boring operations for gas at Dunmore Junction were successful in reaching a supply at about 1200 feet. The upper part of the section passed through in boring, consisted of shales and sandstones with lignitic seams, while the lower part consisted essentially of shales.
17·4 m. 28 km.	**Seven Persons.**—Altitude 2,482 ft. (754 m.). To the south may be seen the extreme western end of the Cypress hills formed here of a low plateau called the Bull's Head. The slopes show some of the light coloured clay characteristic of the top of the Belly River formation. The top of the plateau is probably overlain by Pierre shale.
41 m. 65·9 km.	**Bow Island.**—Altitude 2,608 ft. (793 m.). Between the railway and the South Saskatchewan river several borings for natural gas have been made through the Belly River series to Dakota sandstone near the base of the Cretaceous. A plentiful supply was found at a depth of 2,000 feet (609 m.). The gas is conveyed to Lethbridge and Calgary through a pipe line the total length of which is 180 miles (288 km.).
76·5 m. 123 km.	**Taber**—The Canada West Coal Company operates a small mine situated to the west of the town. The seam, which is horizontal and reached by a shaft about 100 feet (30·4 m.) deep, is at about the same horizon in the Belly River series as the one at Redcliff near Medicine Hat. It has a thickness of 4 feet (1·2 m.) with a parting of 3 inches (7·5 cm.) near the top. The coal is sub-bituminous, approaching

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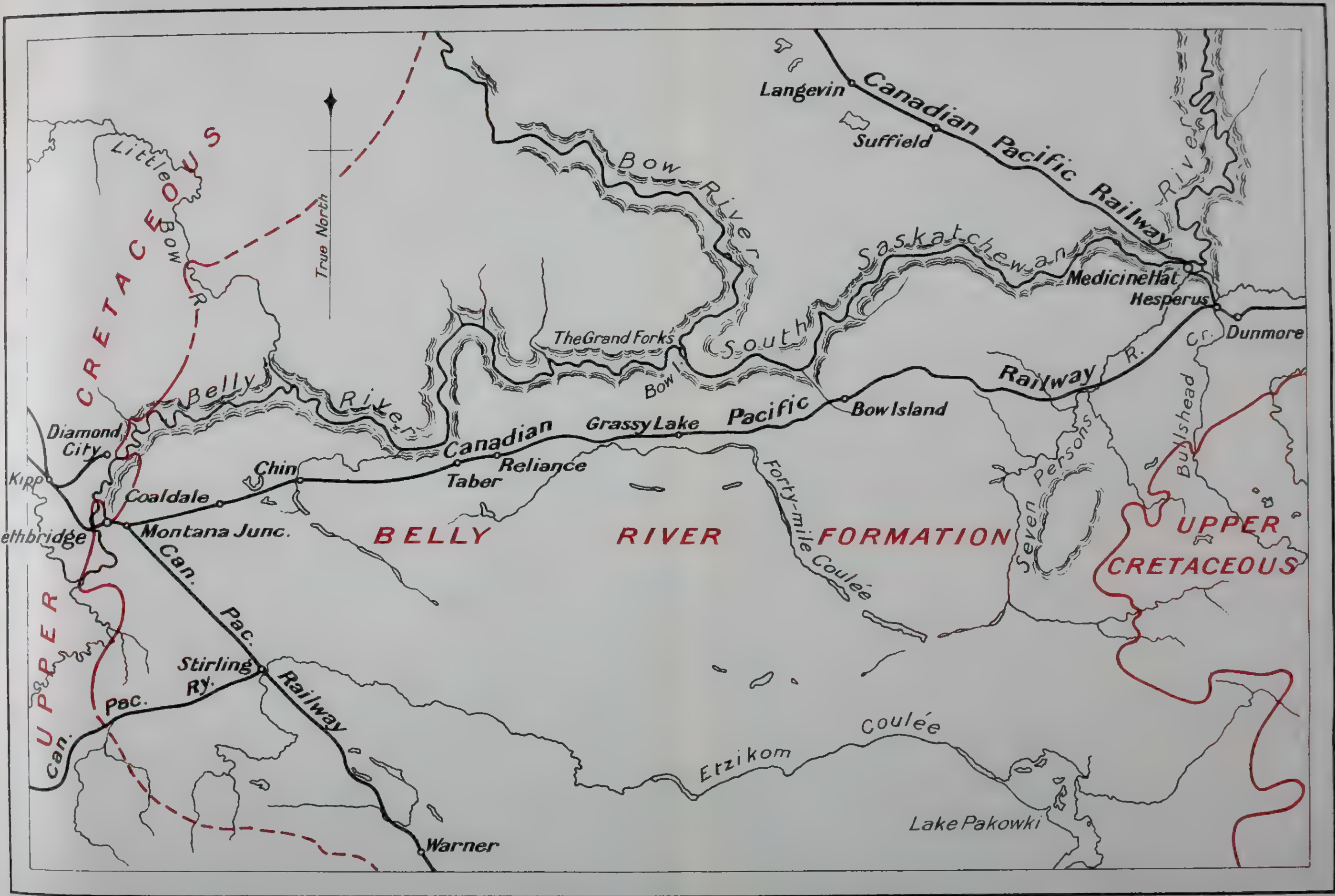


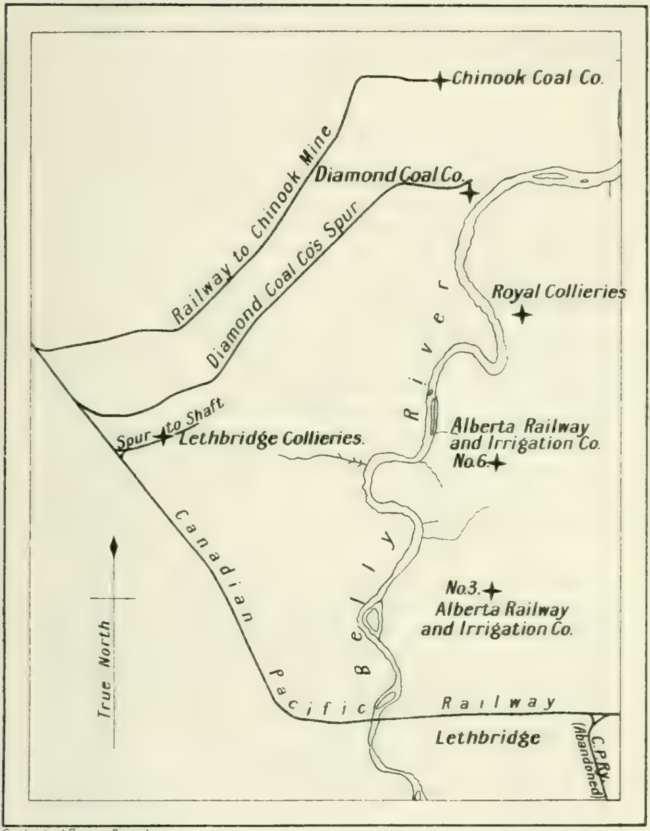
Geological Survey, Canada

Route map between **Medicine Hat** and **Lethbridge**

Miles: 5 0 10 20 30 40

Kilometres: 5 0 10 20 30 40 50 60

C2.



Geological Survey, Canada

Location of the Mines in the Lethbridge District, Alberta.

Miles
1 0 1 2 3
Kilometres
1 0 1 2 3 4

:s and metres. bituminous in grade and is of a better quality than that of Redcliff. It is used locally for domestic purposes.

Between Chin and Coaldale the railway crosses irrigation ditches, which carry water from one of the branches of the St. Mary river to the south.

·4 m. ·4 km. **Lethbridge**—Altitude 2,982 ft. (909 m.). The top of the Belly River series is crossed before reaching Lethbridge and is succeeded by the Pierre shales, sections of which show in the valley of Belly river. Near the water's edge just above the bridge, a coal seam outcrops which is considered to occupy a position at the top of the Belly River series. The valley of the Belly is spanned by a high bridge and from it an excellent view may be had, showing the present stream meandering with gentle current and occasionally swinging into the valley walls and undercutting the softer rocks.

The Lethbridge coal seam is mined in the vicinity of the city. It has a slight dip to the northwest and an average thickness of $4\frac{1}{3}$ feet (1·3 m.).

Four companies are operating at present, namely: the Alberta Railway and Irrigation Company through a shaft 300 feet (91 m.) deep; the Lethbridge Collieries with a shaft 573 feet (174 m.) deep; the Diamond Coal Company by a shaft and a drift tunnel from the river valley; and the Chinook Coal Company through a shaft 425 feet (129 m.) deep. The annual aggregate output amounts to about 400,000 tons.

1 m. km. **Macleod**—Altitude 3,128 ft. (953 m.). This town owes its existence to having been originally an outpost of the Royal Northwest Mounted Police.

m. km. **Brocket**—The centre of the synclinal fold in the rocks of the St. Mary River series is crossed about a mile west of Brocket. At Mile Post 173 between Pincher and Cowley, the western limb of the syncline is crosssed.

187·6 m. 301 km. **Burmis**—Altitude 3,815 ft. (1,162 m.). Near Burmis a great fault, with a downthrow to the east, brings the beds of Lower Cretaceous in contact with the upper members.

THE CORDILLERA.*

BY

S. J. SCHOFIELD.

CLASSIFICATION.

The North American Cordillera occupies the western portion of North America from the Great Plains on the east to the Pacific Ocean on the west.

The size of this Cordillera may be indicated by a comparison with the other great mountain chains of the world. The Himalayas cover about 300,000 square miles (777,000 sq. km.), the Alps of Europe about 70,000 square miles (181,000 sq. km.); the Andes about 1,000,000 square miles (2,600,000 sq. km.); and the North American Cordillera over 2,300,000 square miles (5,961,000 sq. km.).

The subdivision of this vast orographic unit in Southern British Columbia and Alberta is based upon topographic features, the lines of delineation being the axes of the greater valleys and trenches in the mountain complex. As can be readily conceived from the accompanying illustration, in the easterly Alpine belt, the Rocky Mountain trench, the Purcell trench, the Selkirk valley and the Okanagan valley represent partial boundaries of the Rocky Mountain, Purcell, Selkirk and Columbia Mountain systems. The Western Alpine belt includes the Coast and Cascade ranges, separated from the Vancouver range and the Olympic mountains by the Strait of Georgia. Between these two Alpine belts lies the more subdued Interior Plateau region.

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* Mainly an abstract from Memoir No. 38 by R. A. Daly. Geol. Sur., Can., 1913.

Map to illustrate the paper on
the Nomenclature of a part of the
NORTH AMERICAN CORDILLERA
By REGINALD A. DALY.

GEOLOGICAL HISTORY.

The geological history of the North American Cordillera can be clearly expressed with reference to two large geosynclinals; an eastern or Rocky Mountain geosynclinal and a western or Pacific geosynclinal. It can also be shown that previous to the Mesozoic these two geosynclinals, as regards their relative periods of deposition and erosion, bore reciprocal relations to each other.

The Rocky Mountain geosynclinal lies between the Great Plains and the Purcell trench. It embraces sediments from the base of the Belt (pre-Olenellus) terrane up to and including the Mississippian and is composed of a single group of comformable strata varying in composition and texture according to relative proximity to the ancient shore lines which border such basins of sedimentation. The four type sections which illustrate this principle from east to west are the Lewis Galton, Purcell and Summit series which have an average thickness of about 20,000 feet.

During Triassic, Jurassic and Cretaceous, sedimentation was continuous in the middle and eastern part of the Rocky Mountain geosyncline with a probable increase in the area of sedimentation of at least the Cretaceous beyond the Rocky Mountain geosyncline proper. This period of sedimentation was brought to a close by the Laramide Revolution (Eocene), whose effects are seen in the folding and overthrust faulting so characteristic of the structure of the Rocky Mountain system. Since that time, this belt has been subject to denudation, the detritus of which is seen in the Tertiary and superficial deposits of the piedmont belt of the Great Plains.

Passing to the western or Pacific geosynclinal, which lies between the Purcell Trench and Pacific ocean, the earliest record is the important Pre-Cambrian (Archean) sedimentation, leading to the formation of the Shuswap limestones, schists and gneisses, the latter at least partly of igneous origin. From this time until the Mississipian period, the western geosyncline was an area of erosion, which supplied the material for the formation of the Rocky Mountain geosynclinal. At or near the close of the Mississippian, the western geosyncline area was submerged and received a great load of Pennsylvanian sediments and accompanying lava floods. The record for the Jurassic is meagre, indicating that an upheaval of the Triassic sea bottom had begun as an early preparation for the Jurassic revolution. This was closely followed by the intrusion of many large batholiths of granodiorite and related rocks. Erosion of these Jurassic mountains produced the material for the smaller Cretaceous geosynclinals at various points in the Main Pacific Geosynclinal. Orogenic movements, called the Laramide Revolution, and batholithic intrusion followed.

During the Tertiary, erosion was dominant in this belt with accompanying deposition in isolated basins. Sedimentation was interrupted by local folding in late Miocene and Oligocene. Vulcanism was prevalent throughout the Tertiary while batholithic intrusion was confined to the Miocene.

GLACIATION.

In that portion of the North American Cordillera, which is embraced by Southern British Columbia and

Alberta, three glacial provinces stand out in bold relief as shown in the accompanying cut. The middle part of the Cordillera was covered by a continuous ice-cap. To the east of this cap, the Alpine belt which includes the greater part of the Rocky Mountain, Purcell, Selkirk and Columbia systems, was covered by numerous valley glaciers whose direction of flow was regulated in the main by the great master longitudinal valleys. Similarly in the Alpine belt lying to the west of the Interior Plateau region, the direction of the ice drainage was governed by the main depressions in that belt. The continental ice-cap of the Interior Plateau region in Southern British Columbia moved in general in a southerly direction.

PHYSIOGRAPHIC HISTORY.

Foundation for the construction of the present form of the Cordillera was laid at the closing of the Cretaceous period, when the last general orogenic revolution in the Cordillera took place. Mild deformation of the Eocene Oligocene and Miocene formations substantiates the date of this general deformation. The resultant topography superimposed upon a terrane composed of quartzites, hard schists, massive limestones and dolomites, and granites was one of high relief and intricate design. The work of reducing the original chain of early Eocene mountains to the present more subdued relief is of the same order as that accomplished by the erosion of the entire Tertiary period in equally resistant terranes of the Appalachians. The development of the Rocky Mountain and Purcell trenches, the Selkirk and Okanagan valleys, forms a series of tasks comparable to those of opening the Hudson and Connecticut valleys in the east. The many narrow valleys of the Cordillera are analogues of the young to mature Tertiary valleys cut in the Cretaceous peneplain of the Appalachians. During late Tertiary there was an important uplift in the Cordilleran region claimed by Dawson to reach 2,000 feet for the Interior Plateau region. This late Tertiary uplift invigorated the rivers; it did not begin a new erosion cycle at the close of a completed former cycle; hence the entire post-Laramie history belongs to one complex erosion cycle.

BURMIS, ALBERTA TO ELKO, BRITISH COLUMBIA.

BY

W. W. LEACH.

INTRODUCTION.

The territory lying between Burmis, Alberta and Elko, British Columbia, includes all the coal fields, containing high-grade bituminous coal of Kootenay age in the Crowsnest Pass, which are traversed by the Crowsnest branch of the Canadian Pacific railway.

These fields may be broadly divided into two groups, the most easterly lying in the province of Alberta and separated from the westerly or British Columbia group by the main range of the Rocky mountains. Each of these groups consists of a number of separate areas of coal-bearing beds.

On the Alberta side of the mountains the various coal areas are divided by a series of great faults, following closely the strike of the strata, while the individual areas have been subjected to severe folding and some minor faulting. On the other hand, the British Columbia group is composed of a number of more or less regular basins, the most important of which has a length of some 35 miles (56·3 km.) with a maximum width of 11 miles (17·7 km.).

The coal is contained in rocks of Kootenay age (Lower Cretaceous) consisting of hard, grey sandstones, grey, black, and carbonaceous shales with, towards the top, some hard siliceous conglomerate holding many chert pebbles. In the Alberta group the Kootenay rocks have a total thickness of not more than 700 feet (213 m.) containing from 5 to 6 seams of coal with an aggregate thickness of about 50 feet (15·2 m.) [**8**], while a section measured near Morrissey, on the British Columbia side of the Pass, showed 3,200 feet (975 m.) of Kootenay rocks with 216 feet (62·7 m.) of coal contained in seams of over 1 foot (·3 m.) in thickness [**2**]. Similarly the Fernie shales, of Jurassic age, underlying the Kootenay are very much thinner in Alberta than in British Columbia, in the former

having a thickness of about 650 feet (198 m.) while near Fernie, in British Columbia, they attain a thickness of over 3,000 feet (914·3 m.).

The main range of the Rocky mountains, which forms the boundary between Alberta and British Columbia and intervenes between the two groups of coal fields, is composed almost entirely of massive limestone beds which have been determined to be of Devono-Carboniferous age, there apparently having been no break between these two formations. Towards the top, however, the strata become siliceous containing some thin-bedded quartzites and calcareous sandstones. The total thickness of these rocks has been estimated by G. M. Dawson to be about 4,000 feet (1,219 m.) [1].

The following table shows in descending order the various formations in both groups of coal areas with their respective approximate thicknesses.

ALBERTA AREAS.

Name of Formation.	Age.	Description.
Allison Creek (Belly River ?) 1,900 ft. + (579 m.)	Cretaceous....	Soft, light-coloured sandstones, with small coal seams near top.
Benton, 2,750 ft. (838 m.).		Chiefly dark shales with a few hard, siliceous sandstone beds.
Crowsnest Volcanics, 1,150 ft. (350·5 m.).....		Trachytic tuffs and breccias
Dakota, 2,750 ft. (838 m.).......		Chiefly shaly sandstone with plant impressions, usually green in colour.
Kootenay 600 ft. (182·8 m.)......		Sandstones, shales and coal seams.
Fernie, 750 ft. (228·6 m.)..	Jurassic......	Dark shales with a few thin sandstone beds.
Limestone Series, 4,000 ft. (1,219 m.).............	Devono-Carboniferous.	Massive light-grey limestone.

BRITISH COLUMBIA AREAS.

Name of Formation.	Age.	Description.
Flathead beds...........	Cretaceous....	Sandy shales and shaly sandstones.
Elk Conglomerates, including Flathead beds, 6,500 ft. (1981 m.).....	Cretaceous....	Conglomerates, sandstones, and some semi-cannel coal seams.
Kootenay, 1,847 ft. (562·9 m.)............	Cretaceous....	Sandstones, shales and coal seams.
Fernie, 3,000 ft. (914·3 m.)	Jurassic.......	Shales, calcareous towards base.
Limestone Series, 4,000 ft. (1,219 m.).....	Devono-Carboniferous	Massive, light grey limestone.
....	Cambrian......	Siliceous argillites.

There appears to be no great unconformity between the Palæozoic and Mesozoic rocks on either side of the mountains, but the contact between the limestone of the main range and the Allison Creek formation on the eastern slope of the mountains is a faulted one, a great overthrust having caused the limestone to override the Cretaceous sandstone for a distance of several miles. To the east the Kootenay formation is last seen at Burmis station, where another fault of large dimensions with easterly downthrow has brought the Kootenay rocks and Upper Cretaceous strata into juxtaposition.

The coals throughout this district are all of a very similar nature, with the exception of a number of small seams found near Fernie, overlying the main coal measures, which contain coal of a semi-cannel character.

Nearly everywhere the coal cokes readily and is utilized to a large extent in the manufacture of that product; it is generally rather friable, and often contains a somewhat large amount of ash, but it has been found to be eminently

adapted for steam raising purposes and is in much demand by the railways for locomotive use. The following proximate analyses, from air-dried samples, give a general idea of the quality of the coal:—

Locality.	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.	Remarks.
(1) Bellevue No. 1 seam....	0·2	27·5	56·8	15·5	Run of mine coal.
(2) Coleman No. 4 seam....	0·6	23·8	59·5	16·1	do. do.
(3) Michel No. 8 seam....	1·1	23·8	65·0	10·1	Coal, screened and picked at mine.
(4) Hosmer No. 8 seam....	1·3	27·6	63·7	7·4	Coal, hand-picked at testing plant.
(5) Coal Creek No. 2 seam....	1·3	26·0	63·8	8·9	Coal, screened and picked at mine.
(6) Marten Creek	2·10	57·71	30·33	9·86	Cannel coal, surface sample.

Of the above analyses, Nos. 1 to 5 were made at McGill University and have been condensed from the full analyses published in the report on "Coals of Canada" by J. B. Porter and R. J. Durley [**9**].

In the year 1910 a total of 3,137,138 tons (2,000 lbs.) of coal was produced in the district, of which amount Alberta contributed 1,608,205 tons, and British Columbia 1,528,933 tons, from which 121,578 tons of coke were made in the former province and 241,579 in the latter [Refs. **5** and **6**]. In 1911 the output was very much less, due to the fact that for eight months nearly all the mines were idle on account of a miners' strike.

Miles and Kilometres. (from Dunmore)
187·6 m.
301·9 km.

Burmis—Altitude 3,995 ft. (1,217·6 m.). Burmis station is almost exactly on the line of a great fault, the strike of which coincides closely with that of the rocks and is nearly north and south, the railway crossing it approximately at right angles. To the east of the station, on the north side, can be seen a series of light-coloured, soft, crumbly, and in places shaly, sandstones, the exact age of which has not been as yet definetely determined,, but is probably well up in the Cretaceous. The fault with its easterly downthrow has brought these rocks against the Kootenay formation showing a throw of at least 7,000 feet (2,133 m.).

A short way to the west of the station, Kootenay rocks are fairly well exposed on the north side of the track consisting of hard, light-coloured and dark grey sandstones, grey and black shales, and coal seams, the latter being overlaid by a massive bed of very hard, light-weathering, siliceous sandstone, in places conglomeratic, which constitutes the top of the Kootenay. The whole of the Kootenay, usually from 650 to 700 feet (198 to 213) in thickness (**1.**), is not shown here, its base, together with the Fernie shales, having been cut off by the fault. In the vicinity of the fault the Kootenay rocks are quite severely folded, good exposures illustrating this are to be seen near the Davenport Coal Company's tipple.

The Davenport Coal Company has developed six coal seams here, the several thicknesses of which are 3·4 feet (1·0 m.), 5 feet (1·5 m.), 4·6 feet (1·4 m.), 5 feet (1·5 m.), 6 feet (1·8 m.), and 6 feet (1·8 m.). The coal is mined by pillar and stall method and hauled to the tipple by endless rope; the steel tipple is equipped with Marcus screens, built at Newcastle-on-Tyne, and is capable of handling 120 tons per hour.

Miles and Kilometres.

The whole equipment is electrically operated.

After leaving Burmis, the railway follows closely the north bank of the Crowsnest river, good exposures consisting of rocks of the Dakota formation which overlies the coal-bearing Kootenay, being seen for some distance. The Dakota is made up almost entirely of soft, crumbly, dark-coloured, shaly sandstone, and sandy shales often showing obscure plant impressions, the prevailing tints being green, though some very characteristic dark red beds are in evidence. The strata in this neighbourhood are quite extensively folded, and about one mile west of Burmis an important fault occurs with the usual easterly downthrow of several hundred feet.

Police Flat siding—At Police Flat is situated one of the Leitch Collieries' plants. This point is on the axis of a sharp anticline and is underlaid by Dakota rocks, but about half a mile to the north, where the mine is situated, erosion has uncovered the underlying Kootenay beds. Here five seams of coal have been proven, 2 ft. (·6 m.), 6 ft. (1·8 m.), 5 ft. (1·5 m.), 4 ft. (1·2 m.), and 10 ft. (3·04 m.), respectively, in thickness. The mine is worked by pillar and stall system and on account of the steep dip (60°) the rooms are driven diagonally up the pitch. The coal is hauled in the main gangway and to the tipple by gasoline motor. The tipple is of the Phillips cross-over type and is equipped with shaking screens and picking tables, and has a capacity of 1000 tons in two shifts. From the tipple the slack coal is elevated to the washing plant, of Luhrig jig type, with a capacity of 500 tons washed coal in ten hours. After washing, the coal passes to bins holding 1000 tons and thence by electric lorries to the coke ovens, 101 in number; these ovens are a modified bee-hive, rectangular in shape and are mechanically levelled and pushed. They take a charge of 10 tons of coal.

Miles and Kilometres.

Leaving Police Flat the railway crosses rocks of Dakota age, showing several well-marked folds until Passburg station is reached, where the Kootenay beds again appear on the Passburg or western limb of a sharp syncline. On the south side of the river, the Leitch Collieries have opened a small mine on a 5 ft. (1·5 m.) seam.

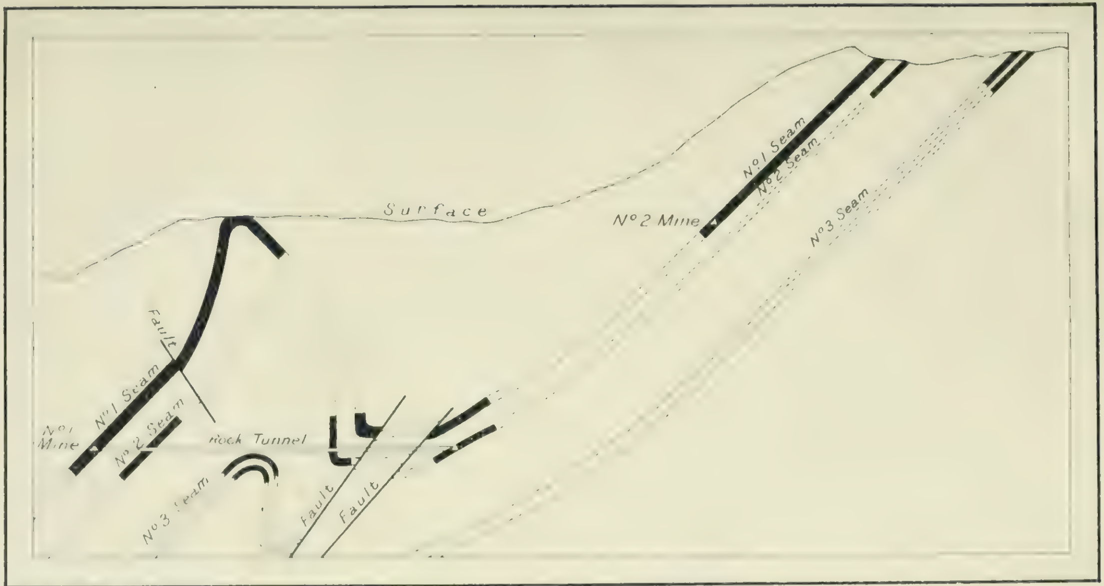
From Passburg to Bellevue siding the railway follows the strike of the rocks, the noticeable steep wall-like ledge on the right-hand side being a massive sandstone immediately overlying the coal measures.

Bellevue siding—At Bellevue the West Canadian Collieries Ltd. are operating an important mine. Four seams intersected by a cross-cut tunnel are 9 ft. (2·7 m.), 17 ft. (5·2 m.) $4\frac{3}{4}$ ft. (1·4 m.), and 15 ft. (4·5 m.), respectively, in width, in a total thickness of 450 feet (137 m.) of measures. Two other seams, one 4 ft. (1·2m) the other $3\frac{1}{2}$ft. (1·06 m.) in thickness are known to occur below these. The coal is worked by pillar and stall system, the rooms being driven directly up the pitch. In driving a crosscut from No 1 seam to intersect the lower seams from a point some two miles (3·2 km.) from the entry, a notable double fold was met with, No. 2 seam having been cut in three places while No. 1 and 3 seams were entirely missed; the accompanying sketch will make this clear.

About one half mile (·8 km.) to the east of Bellevue the Maple Leaf mine is situated. The folding mentioned above is well seen here, the coal seams being repeated four times in a disance of about one half mile (·8 km.). The Maple Leaf mine is one of the few places in this district where fossils have been found in the Kootenay rocks, some good specimens of fossil plants having been collected here.

Leaving Bellevue, the railway continues up the Crowsnest river to Hillcrest station, the intervening country being underlaid by Dakota

C2.



Geological Survey, Canada

Section ... **Bellevue Mine** showing folding of coal seams

Feet
0 100 200 300 400 500
Metres
100 75 50 25 0 100

Miles
Kilom

Miles and Kilometres.

rocks, one well defined anticline occurring near Hillcrest station. At this station

193·0 m. 310·6 km. **Hillcrest** a short spur turns off to the south to Hillcrest town and mine. The mine is located on the western limb of a broad undulating syncline on the eastern limb of which the Bellevue mine is situated. Three seams, 14 ft.(4·2 m.), 8 ft. (2·4 m.), and 9 ft. (2·7 m.) in thickness, have been developed at this point

From Hillcrest station to near Frank the Dakota rocks continue, the railway running diagonally across the above mentioned syncline. A short distance west of Hillcrest station the immense Turtle Mountain rock slide is entered. The great gash in the face of Turtle mountain on the south side of the track can be well seen from Hillcrest station. The slide took place early in the morning of April 29, 1903, and besides wiping out the surface works of the Frank mine and imprisoning some 19 miners, demolished a number of houses in the town of Frank. The total loss of life has never been definitely known, but it is believed to have been in the neighbourhood of 70. Two special reports have been written on the subject of this slide, the first by Messrs. McConnell and Brock in 1903 [**3**], and the second in 1911, by a commission appointed to investigate the condition of the mountain at that time [**7**]. The total area covered by slide material is estimated to be about 1·03 square miles, with an average thickness of 45 feet (13·7 m.). It is estimated that about 90,000,000 tons of rock were displaced.

The limestone of the slide is now being utilized in the manufacture of lime.

194·9 m. 313·7 km. **Frank**—Just beyond the western edge of the slide the town of Frank is entered. Here the Kootenay rocks are again met with on the western limb of the same syncline as that at Hillcrest. The Kootenay beds here are nearly vertical or in places slightly overturned so that the dip is 85 degrees to the west. Turtle mountain to the south and Bluff mountain to the

Miles and Kilometres.

north are composed of Devono-Carboniferous limestone, and are on the axis of an overturned and broken anticline, the contact of the limestone and the Kootenay being a faulted one with easterly downthrow, with the result that the lower beds of the Kootenay and all of the Fernie shales are cut off, and do not reach the surface. The Canadian Coal Consolidated is operating two mines at Frank; the first is opened by a drift parallel to the face of Turtle mountain and driven in a southerly direction. Three seams have been proved but one only, the highest, is being worked; this seam is from 12 to 15 feet (3·6 to 4·5 m.) thick. The coal is hauled along the main level and to the tipple by means of gasoline locomotives. The daily output (July, 1912) amounts to about 300 tons.

No. 2 mine is situated about one-half mile north of No. 1 and is being operated by means of a shaft 330 feet (100·5 m.) in depth. The main level, driven from the bottom of the shaft, runs in a northerly direction towards Bluff mountain. From this mine the daily output is about 450 tons.

LILLE COAL MINE.

From Frank, the Frank and Grassy Mountain railway branches off to the north and follows the valley of Gold creek for about 7 miles. About 5 miles up this line the town of Lille is situated where the West Canadian Collieries are operating their Lille mine. A coal seam 4 to 5 feet (1·2 to 1·5 m.) in thickness has been worked here quite extensively. The mine is operated on the pillar and stall system with compressed air haulage on the main levels, the tipple capacity being about 1,200 tons in two shifts. The company has also a coking plant at this point consisting of a washery for treating the slack coal and a battery of 50 Belgian ovens of the Bernard type.

ANNOTATED GUIDE.

Miles and
Kilometres.

194·9 m. **Frank**—On leaving Frank the valley rapidly
313·7 km. contracts, passing through a narrow gorge between Turtle and Bluff mountains, locally known as the "Gap." At its eastern entrance a large brick building was built some years ago by the Canada Metals Company for the reduction of zinc ores from the Slocan district of British Columbia. It has never been operated. A few hundred yards further west, near the contact of the Kootenay and the limestone, a strong sulphur spring occurs, which, although cold, is largely used for medicinal purposes.

About one and one-half miles (2·4 km.) west of Frank the western contact between the Mesozoic and the Palæozoic rocks is reached. In this case the contact is a normal one, the Fernie shales lying apparently conformably on the limestone. This is the only outcrop of the Fernie east of the Rocky mountains on the line of the railway, but, even here exposures are very infrequent owing to the soft and readily weathering nature of the beds, which consist almost entirely of soft dark shales with a few thin arenaceous beds and, towards the top, a notable bed of dark green, very soft, crumbly sandstone. The Kootenay follows the Fernie in regular ascending order, a hard siliceous conglomerate forming its uppermost member which crosses the valley through the town of Blairmore.

196·7 m. **Blairmore**—Altitude 4,226 ft. (1,633·8 m.).
316·5 km. At this point the West Canadian Collieries are operating a mine on the south side of the railway, with an output from 700 to 1,000 tons a day. The coal seams have also been prospected for some distance north of the track. At Blairmore, the Rocky Mountain Cement Company is utilizing the Carboniferous limestone and the Fernie shales in the manufacture of cement; both materials are quarried in open pits and transported to the plant by

Miles and Kilometres.

aerial trams, the proportion of materials used being five parts limestone to one of shale. During 1911 the output of cement from this plant exceeded 100,000 barrels of 350 lbs. each, the daily capacity being about 1,000 barrels. This company also manufactures lime in three kilns near the cement works, the daily production being about 30 tons. The Fernie shales are being utilized also in the the manufacture of brick by the Keystone Portland Cement Company. The bricks made are of the dry press type and the capacity of the plant is about 20,000 bricks daily.

The quarries of these two companies afford the best exposures of the Fernie shales seen in the district and a number of fossils have been collected from them.

For three-quarters of a mile west of Blairmore the railway crosses the strata in regular ascending order when the Blairmore fault is reached, which brings the top of the Kootenay against the upper beds of the Dakota. To the west of the fault the rocks are seen dipping regularly westward, the Dakota overlying the Kootenay and being succeeded by the Crowsnest volcanics, and they by the Benton-Niobrara formation. The volcanics consist of an important intercalation of trachyte tuffs and flows, at this point having a thickness of about 450 feet (137 m.) but rapidly increasing in thickness to the west. The Benton-Niobrara is composed very largely of dark shales, holding marine fossils, with a few hard sandstone beds [**8**]. It is here about 2,750 feet (838 m.) in thickness. Owing to the soft nature of these shales they have yielded readily to erosion, with the result that they are usually found occupying wide valleys and depressions where exposures are infrequent.

At the eastern end of the town of Coleman, the Benton-Niobrara is succeeded by several hundred feet of soft, whitish sandstone, constituting the base of the Allison sandstones, which is probably referable to the Belly River formation. These beds are cut off by the

Miles and Kilometres.

great Coleman fault, which crosses the valley near Coleman station. The fault follows the strike of the strata closely, and has the easterly downthrow usually found in this district, bringing the Kootenay rocks again to the surface.

200·3 m. 322·3 km. **Coleman**—At Coleman two companies are operating coal mines, one on each side of the valley, The plant and mines of the International Coal and Coke Company (Dennison Colliery) are situated to the south of the railway where five coal seams have been proved, of which No. 2, 15 feet (4·5 m.), and No. 4, 6 feet (1·8 m.) are at present being worked. Both seams are opened by means of levels driven on the strike, the coal being won by pillar and stall method and the rooms driven up the pitch, which is here about 32 degrees.

The capacity of the mine and plant is about 3,000 tons daily.

The coke plant consists of a Bradford breaker and 216 beehive ovens, the coal being delivered to the ovens by electric lorry.

The McGillivray Creek Coal and Coke Company's mine is situated on the north side of the valley about one-half mile from the railway. One seam, from 10 to 12 feet (3 to 3·6 m.) in thickness, the No. 2 of the series, has been developed by means of a slope with levels driven from its foot, the coal being worked by pillar and stall system. From the top of the slope the mine cars are hauled by electric motor along a surface tram to the tipple, a distance of one and one-half miles (2·4 km.). The tipple, of steel construction, is equipped with screens and picking belts and is capable of handling about 2,000 tons in two shifts daily.

In the vicinity of Coleman good sections can be seen of the Kootenay formation on the railway just west of the town and in the bed of Nez Percé creek, near the McGillivray Company's mine, while the Dakota rocks are exposed at frequent intervals for about a mile to the

Miles and Kilometres.

west along the road and railway. Overlying the Dakota rocks the Crowsnest volcanics can be well seen in a number of cuts along the railway to the west of Coleman; they here reach a thickness of 1,150 feet (350·5 m.). Specimens from this locality have been microscopically and chemically examined by C. W. Knight who distinguished four predominant rock types, viz.: augite-trachyte breccia, tinguaite, andesite tuff, and analcite-trachyte tuff [**4**].

From Coleman to the east end of Crowsnest lake, the railway crosses the Cretaceous rocks in regular ascending order, the dip of the strata gradually flattening to nearly horizontal. West of Coleman the valley widens, is more open, and shows well-marked terraces, and good views can be obtained of the Rocky mountains and of Crowsnest mountain. This last named peak, by reason of its isolated position, forms a notable landmark for many miles; it reaches an elevation of 9,125 feet (2,780 m.) or about 4,800 feet (1,219 m.) above the valley. The upper part of the mountain is composed of almost horizontal beds of Palæozoic limestone, which have overridden Cretaceous sandstones of the Allison Creek formation along a great thrust plane. The Palæozoic rocks to the east of Crowsnest mountain have been removed by denudation, the valley of Allison creek forming a low depression, underlain by Cretaceous rocks, between Crowsnest mountain and the main range of the Rocky mountains.

204·3 m. **Sentinel**—A short distance beyond the
328·8 km. east end of Crowsnest lake the contact of the Cretaceous and Palæozoic rocks is crossed, the Cretaceous beds dipping under the Devono-Carboniferous limestone along the overthrust fault-plane already mentioned. Half way up the lake, on the north side, a remarkable spring issues from a large overhung grotto in the face of a limestone cliff, and constitutes the chief feeder of the lake.

All along the north shore of the lake as far as the summit, the Palæozoic rocks are well

36425—3½

Crowsnest mountain from near Coleman.

Miles and Kilometres.

exposed. They consist almost entirely of limestone, usually massive, and often cherty and crinoidal; towards the top of the series a considerable thickness of hard, whitish, calcareous sandstones occurs. The fossils collected from this neighbourhood are mostly characteristic Devonian forms but some of the species represented are known to occur in the Carboniferous. While there is an apparent thickness of nearly 10,000 feet (3,048 m.) of these rocks, it is probable that there is a repetition due to compressed and overturned folding, and that in reality the total thickness does not greatly exceed 3,500 feet (1,067 m.) [**1**].

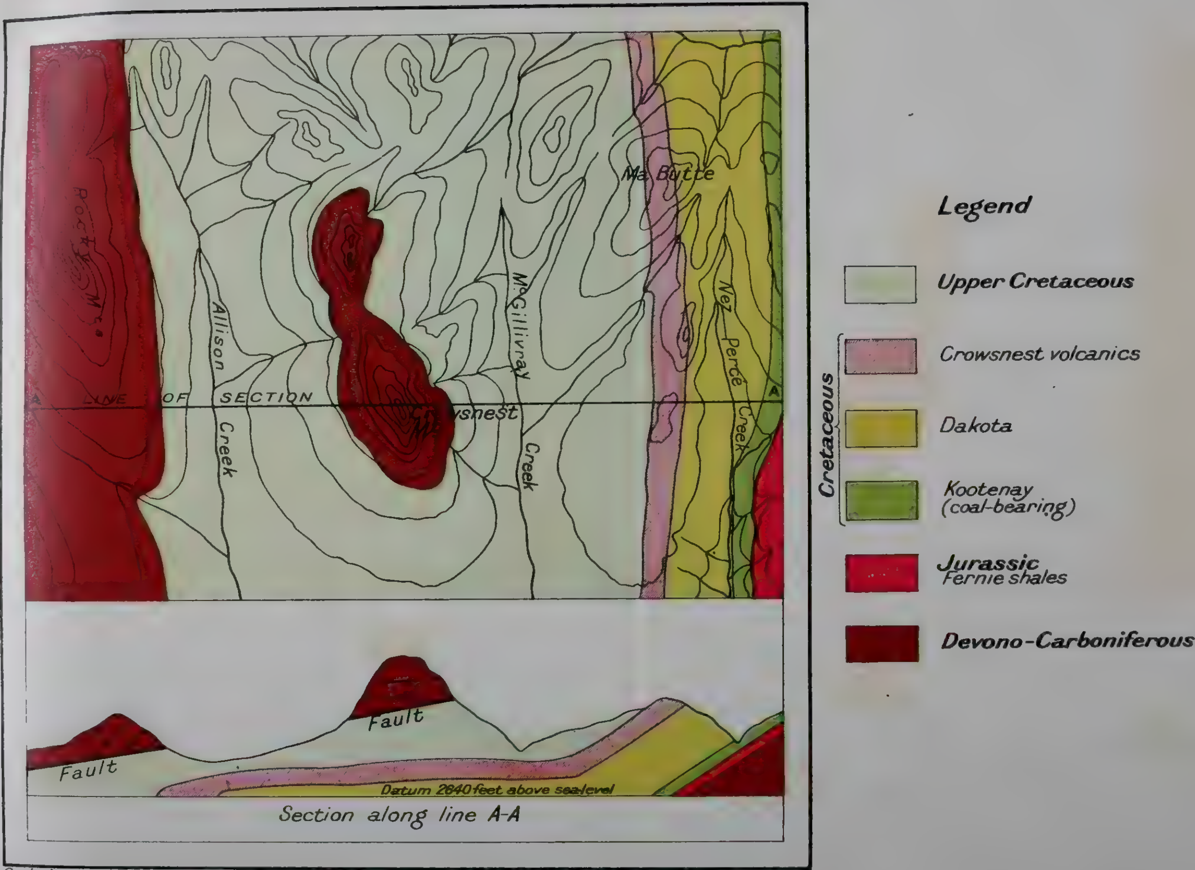
209·6 m. 337·3 km. **Crowsnest**—Altitude 4,449 ft. (1,356 m.). The summit of the Rocky mountains is reached at Crowsnest station at an elevation of 4,449 feet (1,356 m.) above sea level, being one of the lowest passes in the Canadian Rockies. The western approach to the pass being much steeper than the eastern, the railway descends to the valley of Michel creek by a remarkable loop crossing the south fork of that stream at McGillivray station. From Crowsnest to McGillivray the rocks seen belong almost entirely to the limestone series with two small infolds of the dark-coloured Jurassic Fernie shales.

216·3 m. 348·1 km. **McGillivray**—

GEOLOGY OF THE REGION ABOUT CORBIN.

From McGillivray the Eastern British Columbia railway branches off, following up the south fork of Michel creek for a distance of 16 miles (25·7 km.) to the town of Corbin. For most of the way it runs in a wide valley, underlain by the Fernie shales, in which rock exposures are infrequent. Tent mountain and Mount Taylor, to the northeast and southwest of the line respectively, are composed of the coal measures overlying the Fernie shales, and occupy small synclinal basins to the east of the main Crowsnest basin.

Geo



Geological Survey, Canada.

Map and section of **Crowsnest Mountain**
showing overthrust of Palæozoic on Cretaceous rocks

Miles

½ 0 1 2 3

Kilometres

½ 0 1 2 3 4 5

Crowsnest Pass, looking eastward.

Corbin—At Corbin a similar outlying remnant of the coal-measures is being exploited by the Corbin Coal and Coke Company. This company is operating two mines; No. 1 being opened near the valley level by means of a tunnel along the strike of the seam, while No. 2 mine is situated nearly 1,000 feet (305 m.) above the floor of the valley. The geological relationship of these two openings has not as yet been worked out, and it is possible that the same seam is represented at both places. At No. 1 mine the seam is nearly vertical and varies greatly in size, from a minimum thickness of 10 feet (3 m.) to a maximum of nearly 250 feet (76·2 m.); this great difference may be due to compressed monoclinal folding. At the upper mine the coal has been stripped near the top of the hill, and shows the coal in a synclinal basin about 370 feet (112·7 m.) in width; the thickness of the coal near the centre of the syncline having been proved by drilling to be over 100 feet (30·5 m.).

The upper mine is reached from the valley by means of a switch-back railway and the coal is worked in open cuts with a steam shovel. The output in 1910 from No. 1 mine alone amounted to about 142,000 tons.

ANNOTATED GUIDE, (Continued).

Miles and Kilometres.

216·3 m. 348·1 km. **McGillivray**—McGillivray station is situated near the eastern edge of the main Crowsnest coal basin, the rocks having general westerly dips. From the station to the junction of the North Fork with the main Michel creek, where the coal measures proper are entered, the railway follows closely the strike of the Fernie shales.

The Crowsnest basin has a total length along its major axis of about 35 miles (10·6 km.) with a maximum width of 11 miles (3·3 km.), and is estimated to cover an area of about 230 square miles (526 sq. km.). In a section measured near Morrissey 22 coal seams, of one foot (0·3 m.) and over in thickness, were noted, containing in the aggregate 216 feet (65·8 m.) of coal in a total thickness of measures of about 3.200 feet (975 m.). The greater part of the coal,

Miles and Kilometres.

however, consisting of 198 feet (60·3 m.), occurs in a thickness of strata of 1,847 feet (562·9 m.) (**2**). Assuming the extent of the basin to be 230 square miles (526 sq. km.) and the average thickness of workable coal at 100 feet (30·4 m.), the total available supply of coal would be about 23,000,000,000 tons. [**2**].

The coal measures are overlain by a great series of conglomerates, sandstones and shales containing, towards the base, thin seams of coal of a semi-cannel nature and reaching a maximum thickness of from 4000 to 5000 feet (1219 to 1524 m.). It is over comparatively limited areas only, however, that such great thicknesses of the overlying beds are to be found, denudation having removed them to a large extent over the greater part of the basin.

Where crossed by the railway in the valley of Michel creek, the basin has narrowed to about four miles (6·4 km.) in width and the beds overlying the coal measures have been entirely removed by erosion.

222·3 m. 357·7 km. **Michel.**—Alt. 3853 ft. (1174·3 m.).

223·8 m. 360·2 km. **Natal.**—

227·5 m. 366·1 km. **Sparwood.**—Alt. 3637 ft. (1108·5 m.).

At Michel, near the centre of the trough, the Crowsnest Pass Coal Company is operating an extensive colliery and coke-making plant. The company has developed seven seams in all, four on the south side of the valley and three on the north side; of the former the seams designated upper No. 3, No. 3, No. 4 and No. 5, have the following respective widths: 10 to 12 ft. (3 to 3·6 m.), $4\frac{1}{2}$ to $5\frac{1}{2}$ ft. (1·3 to 1·6 m.), 6 to 8 ft. (1·8 to 2·4 m.) and 6 to 8 ft. (1·8 to 2·4 m.), while on the north side, No. 7 seam is about $11\frac{1}{2}$ feet (3·5 m.) thick with a $2\frac{1}{2}$ foot (·76 m.) parting; No. 8 is from 8 to 14 (2·4 to 4·2 m.) and No. 9 is about 10 feet (3 m.) thick. No. 9 seam has not been worked for some years. All the mines at Michel, with the exception of No. 3, are worked by the pillar and stall method: in No.

Miles and Kilometres.

3 the longwall system is in use. A total of 486 beehive coke ovens have been built at Michel.

From Michel the railway continues down the valley of Michel creek in a northwesterly direction, for a further distance of four miles (6·4 km.) when the wide valley of the Elk river is entered. Elk river here flows in a general southwesterly course and follows closely the strike of the rocks, consisting of the Fernie shales which here reach a much greater thickness than on the eastern side of the Pass. The Fernie shales, of Jurassic age, are composed for the most part of dark shales, often arenaceous, and passing towards the base into shaly limestone and calcareous shales [**2**]. Owing to their soft, non-resistant qualities, they have yielded to pressure more readily than the harder overlying rocks and in consequence are often highly flexed and broken. Good sections of these rocks are also difficult to obtain so that any estimate of their thickness must be only approximate, but it is probable that it exceeds 3000 feet (914 m.).

From the mouth of Michel creek to Morrissey creek, a distance of about 28 miles (45 km.), Elk river follows the upturned edges of the Fernie shales, the high mountains to the west of the valley being built of Devono-Carboniferous limestone, while the western edge of the Cretaceous rocks forms a ridge or escarpment which runs parallel to Elk river on the east side of the valley. The height of the escarpment is fairly uniform, being 3500 to 4000 feet (1067 to 1219 m.) above the river, while the base of the coal measures outcrop at elevations of from 1500 to 2000 feet (457 to 609 m.) above the valley, and dip to the east, at angles of from 30 to 65 degrees.

237·8 m. **Hosmer**—Alt. 3447 ft. (1050·6 m.). At
382·7 km. Hosmer the colliery of the Department of Natural Resources of the Canadian Pacific railway is situated. A rock tunnel, across the measures, has been driven at a point 600 feet

Miles and Kilometres.

(182·8 km.) above the railway for a distance of 4931 feet (1,508 m.) which has cut ten coal seams of the following dimensions:—

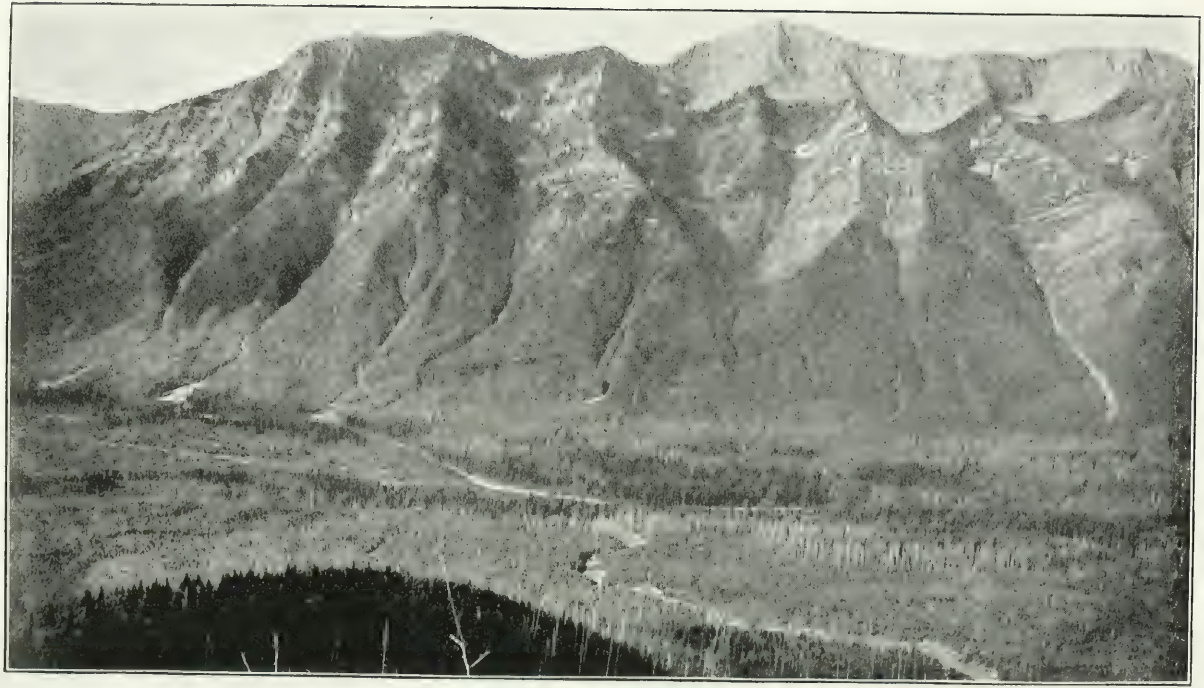
No. 1	seam,	18 feet (5·4 m.).
No. 2	"	12 feet (3·6 m.).
No. 3	"	22 feet (6·7 m.).
No. 4	"	4 feet (1·2 m.).
No. 5	"	5 feet coal, (1·5 m.). 10 inch parting, (25·4 cm.). 13 feet coal, (3·9 m.).
No. 6	"	8 feet 8 ins. (2·6 m.).
No. 7	"	4 feet (1·2 m.).
No. 8	"	5 feet (1·5 m.).
No. 9	"	8 feet (2·4 m.).
No. 10	"	large seam.

Of these seams Nos. 2, 9 and 10 are at present being worked and it is probable that Nos. 9 and 10 correspond to seams Nos. 2 and 1, respectively, of the Coal Creek colliery. The lowest seams, first cut in the tunnel, have easterly dips of 65° degrees, the dip flattening from there on to a minimum of about 25 degrees. In addition to the tunnel seams, the company is operating a mine on the outcrop of the coal where No. 2 seam is being worked by means of a slope; this point being several hundred feet higher than the tunnel entry.

From the tunnel the coal is lowered to the tipple level by a seam-actuated, double-track incline, and thence hauled to the tipple by air locomotives. The tipple, of steel construction, is equipped with screens and picking belts, and has storage bins with a capacity of 2,600 tons of coal and 2,400 tons of slack. The slack coal is treated in a Robinson washer of 400 tons daily capacity, the washed product being utilized in the manufacture of coke in a battery of 240 beehive ovens.

From Hosmer to Fernie the railway continues along the east bank of Elk river, and occasional exposures of the Fernie shales may be seen.

245·5 m. **Fernie**—Altitude 3,302 ft. (1,006·4 m.).
395·1 km. Fernie, a town of about 5,000 population, is the British Columbia headquarters of the Crowsnest



Mountains west of Elk river near Fernie.

Miles and Kilometres.

Pass Coal Company; from here the Morrissey, Fernie and Michel railway branches off and follows the valley of Coal creek up for a distance of five miles (8 km.) to the Coal Creek colliery.

GEOLOGY IN THE VICINITY OF COAL CREEK.

Coal creek is a tributary of the Elk river from the east, which occupies a comparatively deep valley cut through the Cretaceous rocks, thus affording a suitable railway grade to the point where the valley floor rises to meet the easterly dipping coal measures. Here the mines are situated. The coal seams strike approximately at right angles to the valley, thus enabling tunnels to be driven on the seams on each side of the creek, while, as this point is approaching the centre of the basin, the seams dip at much lower angles (12 to 18 degrees) than at their outcrop along Elk river escarpment. The company is working five seams here while several others have been prospected to some extent. The seams being worked with their several thicknesses, are as follows:—

No. 1	Average	thickness	10 feet (3 m.)
No. 2	"	"	$4\frac{1}{2}$ feet (1·37 m.)
No. 5	"	"	12-14 feet (3·6 to 4·2 m.)
A	"	"	8 feet (2·4 m.)
B	"	"	$3\frac{1}{2}$ feet (1·6 m.)

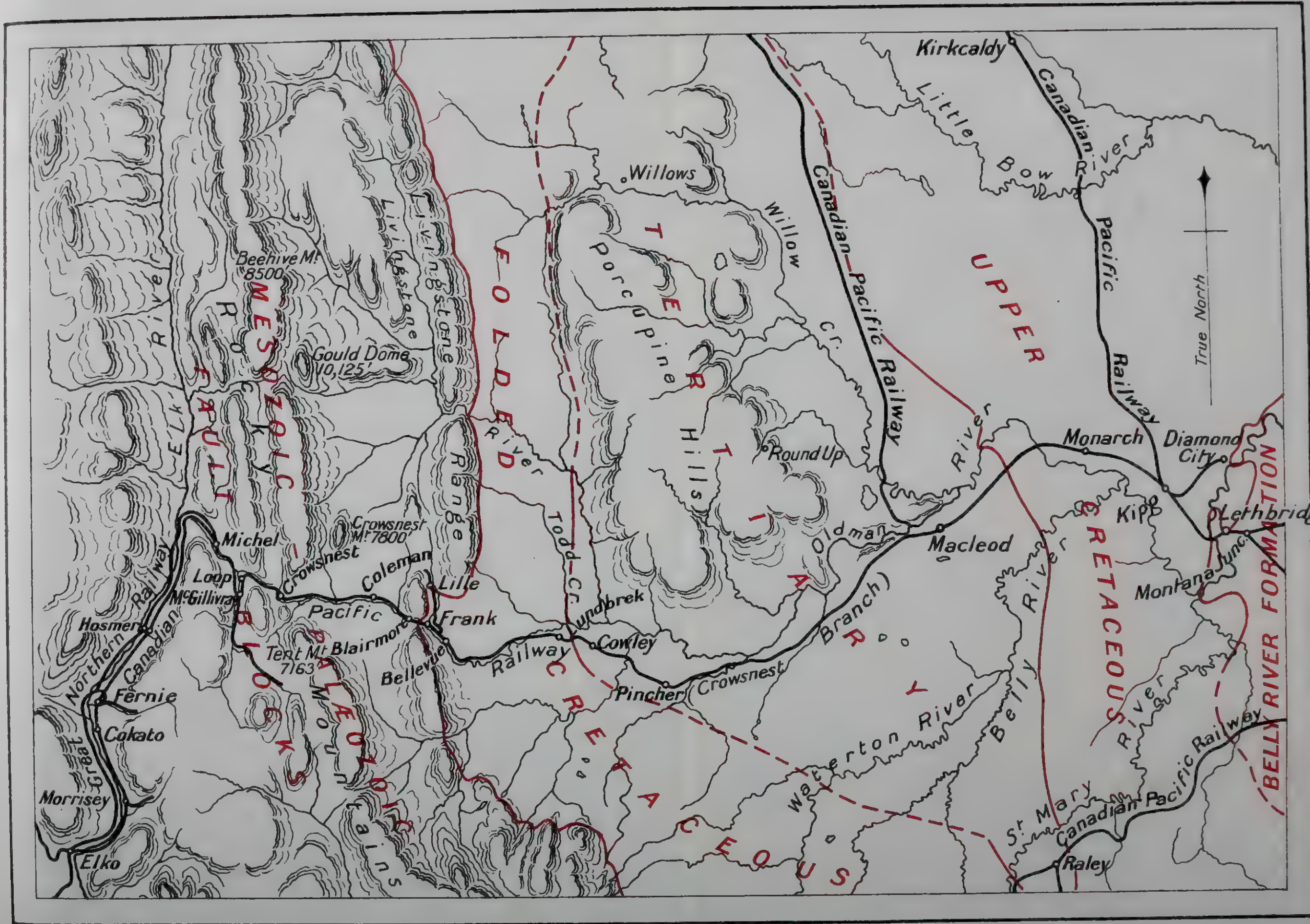
Seams Nos. 1, 2 and 5 are the ones most extensively worked; Nos. 1 and 5 being opened on the north side of the valley, while three mines are being operated on No. 2 seam, viz.—No. 9 mine on the north side and Nos. 2 and 3 on the south side of the valley. The coal from all the seams except No. 2 is mined by the pillar and stall method, whereas, in the mines on No. 2 seam, the longwall system is in use. Inside the mines, haulage is by horses and air locomotives, while all the coal from the various mines is hauled to the same tipple from the several entries by steam or electric motors. The tipple, a steel structure 840 feet in length, which bridges the valley, is of the Heyl and Patterson revolving side dump pattern, and is capable of handling 4,000 tons daily. It is electrically driven and equipped with the necessary screening and picking appliances. The slack coal is stored in large bins at Fernie and is utilized there in making coke, 452 beehive ovens being in operation.

Miles and
Kilometres.

245·5 m. **Fernie**—Altitude 3,302 ft. (1,004·4.). From
395·1 km. Fernie to Morrissey the railway
248·0 m. **Cokato**— continues down Elk river valley,
399·1 km. here wide and flat with few rock
254·0 m. **Morrissey**—exposures. At Morrissey another
408·8 km. branch of the Morrissey, Fernie
and Michel railway leads up the north side of Morrissey creek to the Carbonado colliery of the Crownest Pass Coal company. The Carbonado mines have been idle for some years, although at least nine seams have been worked at different times, and a large plant, including 240 coke ovens, installed. The extremely gaseous nature of the coal at this point, resulting in a number of serious ourbursts of gas, has caused it to be considered expedient to abandon this colliery for the present.

On the south side of Morrissey creek and extending to the south branch of Michel creek on the eastern edge of the coal basin, the Dominion Government holds in reserve a block of 45,000 acres of coal land, being part of a total reserve of 50,000 acres, the remaining 5,000 acres being situated to the northeast of Hosmer.

Shortly after crossing Morrissey creek the railway passes out of the basin of Mesozoic 1ocks and enters into a belt of Devono-Carboniferous limestones, the valley becoming narrower and rock exposures more frequent. The Palæozoic rocks continue for about five miles (8 km.) when their contact with an older series, consisting of siliceous argillites, possibly of Cambrian age, is crossed. The contact is a faulted one. These beds continue to Elko near which place
263·7 m. **Elko**—Alt. 3,082 ft. (939·4 m.) excellent
424·4 km. sections may be seen in a canyon in the valley of Elk river.



Geological Survey, Canada

Route map between Lethbridge and Elko

Miles
5 0 10 20 30 40

Kilometres
5 0 10 20 30 40 50 60

Mountains east of Elk river, showing Coal measures near Morrissey.

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ELKO TO KOOTENAY LAKE, BRITISH COLUMBIA.

BY

S. J. SCHOFIELD.

INTRODUCTION.

The Purcell range, which lies between Elko and Kootenay Lake is made up of rocks which form the western part of the ancient group of sediments deposited in the Rocky Mountain geosyncline. These sediments, called the Purcell series, consist of a great thickness of fine-grained quartzites, argillaceous quartzites, argillites, and lime-

stones of Pre-Cambrian, and Cambrian age. At various horizons in the above series, shallow water characteristics, including ripple marks, mud cracks, and casts of salt crystals, are very common. The Purcell series extends across the International Boundary line into Idaho and Montana, while to the north geological exploration has, up to this time, been insufficient for the exact determination of its extension in that direction. To the west, on account of batholithic intrusions, the relations are not very clear, but there is sufficient evidence to prove the existence of numerous patches of "Archean" schists on the slopes of the Purcell trench (Kootenay Lake valley). This ancient acidic terrane probably represents part at least of the old land from which the quartzitic Purcell series was derived. The stratified members of the Purcell range pass under the younger formations of the Rocky mountains to the east.

The small cross-cutting bodies of granite and porphyritic granite, which intrude the Purcell series, are considered to be small cupola-like stocks, bearing a genetic relationship to the great West Kootenay granite batholith desscribed in the succeeding section of this guide book.

TABULAR DESCRIPTION OF FORMATIONS.

Pleistocene and Recent		Unconsolidated gravels and sands.
	Unconformity.	
Jurassic?		Dyke intrusion: aplites, lamprophyrs and porphyritic granite.
	Kootenay granite	Granite and porphyritic granite.
Mississippian.	Wardner limestone.	Grey limestone. Thickness 1,000 + ft. (305+m.).
Devonian		Limestone and shale. Thickness 500 + ft. (150+m.).
Cambrian ?	Roosville formation	Green siliceous argillites. Thickness 600 ft. (183 m.) (Daly).
	Phillips formation	Purplish-red and green siliceous argillites and sandstones. Thickness 550 ft. (167 m.) (Daly).
	Gateway formation	Light grey quartzites, siliceous dolomites and limestone. Thickness 2,025 ft. (617 m.) (Daly).
	Purcell lava	Amygdaloidal basalt. Thicknees 300 ft. (91 m.).
	Siyeh formation	Thin-bedded green and purple mud cracked shales; some limestone. Thickness 4,000 ft. (1,220 m.). (Daly).

Pre-Cambrian.	Kitchener formation	Thin-bedded dark grey argillaceous quartzites and limestones. Thickness 4,500 ft. (1,372 m.).
	Creston formation	Light grey argillaceous quartzite. and purer quartzites. Thickness 5,000 ft. (1,525 m.).
	Aldridge formation	Rusty weathering heavy and thin-bedded argillaceous quartzites and slates. Numerous sills of gabbro at various horizons. Thickness 6,000+ft. (1,830+m.)

DESCRIPTION OF FORMATIONS.

ALDRIDGE FORMATION.

The Aldridge formation is the oldest known sedimentary member of the Purcell series in the Purcell range. It consists of argillaceous quartzites, purer quartzites, and a subsidiary amount of argillite. The beds have an average thickness of 6 inches (15·2 cm.) but vary from a few inches in the argillitic members to eight feet (2·4 m.) in the purer quartzites. The argillaceous quartzites are grey to almost black in colour on fresh fracture. They weather to a rusty brown, and since the argillaceous quartzites are in greater abundance, they give the characteristic reddish-brown colour to the formation as a whole. The thick bedded purer quartzites weather to a light grey colour. Shallow water features, except some conglomerates on Goat river, are not noticed in the Aldridge formation. In places, cubes of pyrite are abundant. A fact, worthy of emphasis, is that in this region the Aldridge formation is characterized by the presence of a relatively large number of thick gabbro sills, called the Purcell sills. The succeeding younger formations contain only a few gabbro sills, and these are relatively thin and unimportant. The Aldridge formation contains the greatest number of economic ore-deposits, and in it are situated the St. Eugene, Society Girl, Aurora, North Star, and Sullivan ore-deposits. Also, the majority of the copper-bearing veins occur in the gabbro sills which are intruded into the Aldridge formation.

CRESTON FORMATION.

The Creston formation rests conformably upon the Aldridge formation. A transition zone, 500 feet (152·4 m.) in thickness, separates these two formations. The formation consists of a well bedded series of grey argillaceous quartzites, purer quartzites and sandstones with thin intercalations of argillite. The beds are often cemented together so that they form steep cliffs. In the western part of the range these strata resemble coarse sandstones in appearance, while, in the eastern part, the quartzites are finer grained and more argillaceous. The general weathering colour of the lower part of the Creston formation is whitish grey.

KITCHENER FORMATION.

The Kitchener formation consists of thin bedded calcareous argillites, calcareous quartzites, argillaceous quartzites, and limestones, having a thickness of 4,500 feet (1,368 m.). These strata weather reddish brown. Ripple marks and mud cracks occur in them at several horizons. Intruded into the formation are a few diorite sills, some reaching a thickness of 100 feet (30·5 m.).

SIYEH FORMATION.

Lying conformably on the Kitchener formation and passing into it by gradual transition is the Siyeh formation, which consists of purple and grey siliceous argillites in beds from 1 inch to 2 inches (2·54 to 5·08 cm.) thick. Some dolomites and limestones are present in the upper part of the formation. The argillites are characterized by the presence of abundant mud cracks and ripple marks.

PURCELL LAVA.

The Siyeh epoch was brought to a close by the out pouring of a basalt, called the Purcell lava. This lava consists almost entirely of amygdaloidal basalt with small amounts of rhyolite and breccia, and is the extrusive phase of Purcell sills.

PURCELL SILLS.

The Purcell sills are not only of scientific interest but, economically, they contain small deposits of copper ores. The sills occur as sheets of igneous material from 6 to 2,000 feet (1·8 m.—609 m.) in thickness, intruded between the bedding planes of the quartzites, and occasionally as very small pipes about 400 feet (121·6 m.) in diameter. Most of these sills are composed of gabbro, but a few show great variations within the same magmatic chamber. The same sill, although believed to be simple in character, is heterogeneous in composition, that is to say processes of differentiation have evidently affected the magma of these sills before solidification with the result that the material of some of the sills is stratified according to density. In this case, a granite layer appears at or near the upper contact of the sills, passing downwards into gabbro. The thickness of the granitic layer bears no relation to the thickness of the sill. The sills have probably been affected by all the movements which the enclosing sediments have undergone, and hence occur in all attitudes, from horizontal to vertical. The sills have evidently reached their present stratigraphic position through fissures, although very few dykes have been found within the region examined. The age of these intrusives is probably Cambrian.

GATEWAY FORMATION.

The lower part of the formation consists of alternating bands of massive concretionary siliceous dolomite and limestone, weathering buff, and massive light grey quartzites. These are succeeded by thin bedded, sandy, argillites and greenish-grey, siliceous, argillites. The sandy argillites weather a light buff and are characterized by the presence of abundant casts of salt crystals.

PHILLIPS FORMATION.

The Gateway passes gradually into the overlying Phillips formation which consists of dark, purplish, and red metargillites, and sandstones with thin laminae of greenish siliceous argillite intercalated at several horizons.

ROOSVILLE FORMATION.

The Phillips is overlain conformably by the Roosville, which consists almost entirely of massive, laminated, green, siliceous, metargillites weathering greenish-grey.

DEVONIAN LIMESTONE.

In the Rocky Mountain system, the Devonian limestone apparently rests conformably upon the underlying Cambrian (?) series, while in the Purcell range to the west, an apparent uncomformity separates the Devonian limestone from the Gateway formation. The staple rock of the Devonian is a massive, dark grey, limestone weathering a whitish-grey colour. The following fossils are found in the limestone:—

Atrypa reticularis.
Spirifer pinionensis.
Orthothetes chemungensis var. arctostriatus.

WARDNER FORMATION.

The dominant rock of the Wardner formation, which lies conformably upon the Devonian, is a whitish-grey crystalline limestone, occurring in beds from a fraction of a foot to four feet (1·2 m.) in thickness.

The following fossils are contained in the limestone:—

Camarophoria explanata (McChesney)
Camarotoechia cf. C. metallica (White)
Composita madisonensis (Girty)
Cleiothyrdina crassicardinalis (White)
Spirifer cf. S. centronatus (Winchell)
Productella cooperensis (Swallow)

The above fossils point to a Mississippian age, Lower Carboniferous, for the Wardner limestone.

KOOTENAY GRANITE.

The Kootenay granite, occurring as small stock-like masses, cuts all the members of the Purcell series in East Kootenay. The peculiar alignment of these bodies of granite along the lines of major faulting of the region cannot be accidental. It shows that the intrusion of the

Elk River canyon near Elko, B.C., showing the horizontal argillaceous quartzites of the Roosville formation.

granite magma accompanied or followed the principal orogenic movements which affected the Purcell range. Cutting the granite itself as well as the sediments in the neighbourhood of the granite, are aplite, lamprophyre, and pegmatite dykes which record the last known igneous activity in the Purcell range.

PLEISTOCENE DEPOSITS.

Lying unconformably on the old eroded surface of all the bed rock formations is a partly consolidated stratified series of clays and sands, into which the streams have incised their beds, leaving well developed terraces at various elevations above their flood plains. In the neighbourhood of the St. Eugene mission two seams of lignite are found in the stratified clays of the Pleistocene.

REGIONAL STRUCTURE.

The Rocky Mountain geosyncline, which includes the greater part of the Selkirk, Purcell, and Rocky Mountain ranges, consists of Pre-Cambrian, Palæozoic, and Mesozoic sediments. Their western border passes through Cœur d'Alene, Kootenay, and Shuswap lakes, along whose shores is exposed the old crystalline complex, from which part of the above sediments was derived.

The Rocky mountains on the east are separated from the Purcell range on the west by the wide Kootenay-Columbia valley. This topographic feature, which is of first importance in the structure of the region, is called the Rocky Mountain trench. The rocks which form the greater part of the Purcell range are probably Pre-Cambrian in age, and their structure is of an entirely different character to that of the Rockies. The Purcell sediments were first folded into a series of northerly plunging anticlines and synclines. Later these folds were truncated by normal faults which strike in a N.E-S.W. direction and hence trend in a direction at right angles to those of the Rocky mountains. It is probable also that the fault system of the Rockies truncates that of the Purcells, for, in the Rocky Mountain trench, a block of Mississippian limestone is down-faulted in contact with the Pre-Cambrian quartzites, and this block trends in a N.W.-S.E. direction. From the above facts it is probable that the

Elk River canyon near Elko, B.C., looking southwards.

Purcell range was built prior to the Rockies, and that the two ranges are structurally separated by the Rocky Mountain trench.

Miles and Kilometres. (From Dunmore.)

ANNOTATED GUIDE.

263·7 m.
421·9 km. **Elko.**—Altitude 3,040 ft. (924 m.). On the hill to the north is exposed a section showing the transition from the Cambrian (?) quartzites at the base of the hill to the lower Palæozoic limestones at the summit. Elk river, which above this point had been flowing in a hanging valley, now swings to the southwest, and enters a narrow canyon carved into the flat-lying Cambrian, argillaceous quartzites, and joins Kootenay river at grade about 15 miles, (24 km.) southwest of Elko. At Elko, which is situated on the extreme western edge of the Rocky Mountain system, the Kootenay River valley is entered. The railway pursues a northeasterly course across this valley, whose floor is covered with stratified Pleistocene gravel, sands, and silts. A knob and kettle topography is a prominent feature of this valley. In this floor covering, the Kootenay river has intrenched itself in a meandering course, whose flood plain is wider than its meander belt. The river itself is crossed just before reaching Wardner.

286·7 m.
461·0 km. **Wardner.**—Altitude 2,434 ft. (740 m.). At the end of the railway bridge over the Kootenay, the Mississippian limestone (Lower Carboniferous) is exposed and contains the fossils enumerated on page 51. This limestone is in contact, on its eastern and western boundaries, with the non-fossiliferous Cambrian or Pre-Cambrian argillaceous quartzites. The high range to the east is the western slope of the Rocky mountains which rise wall-like to an elevation of nearly 10,000 feet (3,048 m.). They are composed of Cambrian or Pre-Cambrian sedimentary rocks. From Wardner the railway runs over the Mississippian limestone, which occupies the bottom of the Kootenay valley. From the car the terraces of Kootenay river are distinctly visible.

Kootenay valley, (Rocky Mountain trench) looking eastwards at the abrupt western face of the Rocky mountains.

Miles and
Kilometres.

294·7 m.
471·5 km. **Mayook**—The mountain on the left (to the west) is composed of rocks of the Siyeh formation, and shows outcrops of Purcell lava. From Rampart (298·8 miles, 498 km.) to Eager, (303·7 miles, 506·1 km.) the railway runs through the Isadore canyon, in which are exposed the Creston quartzites, and argillaceous quartzites.

At Eager the railway runs in a south-westerly direction to Cranbrook.

308·7 m.
493·9 km. **Cranbrook**—Alt. 2,964 ft. (901 m.). Cranbrook is the thriving capital of East Kootenay, whose chief industries are mining, lumbering and agriculture. From this point the railway pursues a south-easterly course, crossing, near Cranbrook, the unexposed conformable contact of the Aldridge and Creston formations.

At a point 3·3 miles (5·2 km.) west of Cranbrook is an exposure of the hornblende gabbro of the Purcell sills occurring in the Aldridge formation. Beyond this the sill can be seen outcropping in the steep cliffs on the western side of the railway.

314·1 m.
500·9 km.
316·8 m.
506·8 km. **Loco-Wattsburg**—At Wattsburg, in the hill on the east side of the railway, can be seen two gabbro sills intruded into the Aldridge quartzites, which lie approximately flat. Half way up the hill the quartzites are seen separating the two sills. The valley which enters from the west is the pre-glacial valley of Moyie river, which at present occupies a narrow canyon behind the hill to the south-west. From Wattsburg the railway follows the pre-glacial valley, which is eroded in the Aldridge formation. The numerous rock cuts along the railway expose the hornblende gabbro of the Purcell sills. At the crossing of Moyie river, 2·8 miles (4·5 km.) west of Wattsburg, the pre-glacial and post-glacial valleys can be seen. The trough-shaped cross-section of the pre-glacial channel here stands out in contrast

Miles and Kilometres.

with the V-shaped cross-section of the post-glacial channel. At this point the river enters its pre-glacial valley and flows southwards into Upper Moyie lake, where the unexposed fault between the Aldridge and Kitchener formations is crossed.

322·9 m.
516·6 km. **Jerome**—Alt. 2,997 ft. (911 m.). Just before reaching Jerome the train passes through a tunnel driven through the dark grey argillaceous quartzites of the Kitchener formation, which is also exposed in the numerous rock cuts along the shore of the lake. At a point 2·3 miles (3·6 km.) west of Jerome the transition rocks between the Aldridge and Creston formations are exposed.

325·7 m.
521·1 km. Half a mile (0·8 km.) farther west, the rocks show numerous ripple marks and mud cracks. Here also, the railway swings around the nose of the northerly plunging anticline in which Moyie valley has been eroded. The axial part of the anticline is composed of the argillaceous quartzites of the Aldridge formation, while the radial portion is made up of Creston quartzites.

328·6 m.
525·7 km. **Moyie**—Alt. 2,997 ft. (911 m.). From this point the plunging contact between the underlying reddish-brown weathering argillaceous quartzites of the Aldridge formation, and the greyish quartzites of the Creston, can be seen on the mountain side to the west. This contact is the same one noted on Upper Moyie lake. On the hill to the east is situated the famous St. Eugene silver-lead deposit, the value of whose products, up to 1911, amounted to $10,394,520. From Moyie to Yahk the bed rock consists of the argillaceous quartzites of the Aldridge formation which are exposed in the many rock cuts along the railway.

349·5 m.
559·2 km. **Yahk**—Alt. 2,717 ft. (825·9 m.). At a point 1·9 miles (3 km.) west of Yahk the unexposed conformable contact of the Aldridge and Creston formations is crossed. This is the same contact which was crossed on Upper Moyie lake.

Miles and Kilometres.

354·6 m. 567·3 km. **Goatfell**—Alt. 2,857 ft. (868·5 m.). In this vicinity the railway again enters an area of Aldridge argillaceous quartzites, belonging to the same block which was examined at Wattsburg.

364·1 m. 582·5 km. **Kitchener**—Alt. 2,393 ft. (727·4 m.). At a point 3,642 feet (1107 m.) west of Kitchener, a differentiated gabbro sill is exposed in the rock cut. The hornblende gabbro, which occupies the unexposed base of the sill, passes by gradual transition into fine-grained granite, which forms the interior of the sill. The upper portion of the sill is composed of hornblende gabbro.

370·8 m. 593·3 km. **McNellie**—At the crossing of Goat river, about half a mile (1·1 km.) west of McNellie, the Aldridge argillaceous quartzites, which are approximately horizontal, are exposed in the canyon. At this point the river leaves the hanging valley of its upper course, and enters Kootenay river at grade about six miles (10 km.) to the west.

376·2 m. 601·9 km. **Creston**—Alt. 1,942 ft. (590·3 m.). At Creston the delta of Kootenay river is seen. This is the same river which was crossed at Wardner where it pursued a southerly course. It turns in a semicircle in the State of Idaho, U.S.A., and flows north into Kootenay lake at Kootenay Landing.

From Creston the railway runs in a north-westerly direction along the western edge of Kootenay Lake valley, (Purcell Trench). At a point 8·7 miles (13·9 km.) north-west of Creston, the first granite intrusion is met with, and occurs cutting the argillaceous quartzites of the Aldridge formation. As the train proceeds, the amount of granite exposed becomes greater until at Sirdar, the southwestern edge of the West Kootenay granite batholith is reached.

388·5 m. 601·6 km. **Sirdar**—From Sirdar the railway crosses the delta of the Kootenay and arrives at Kootenay Landing.

Miles and
Kilometres.

391·7 m.
626·7 km.

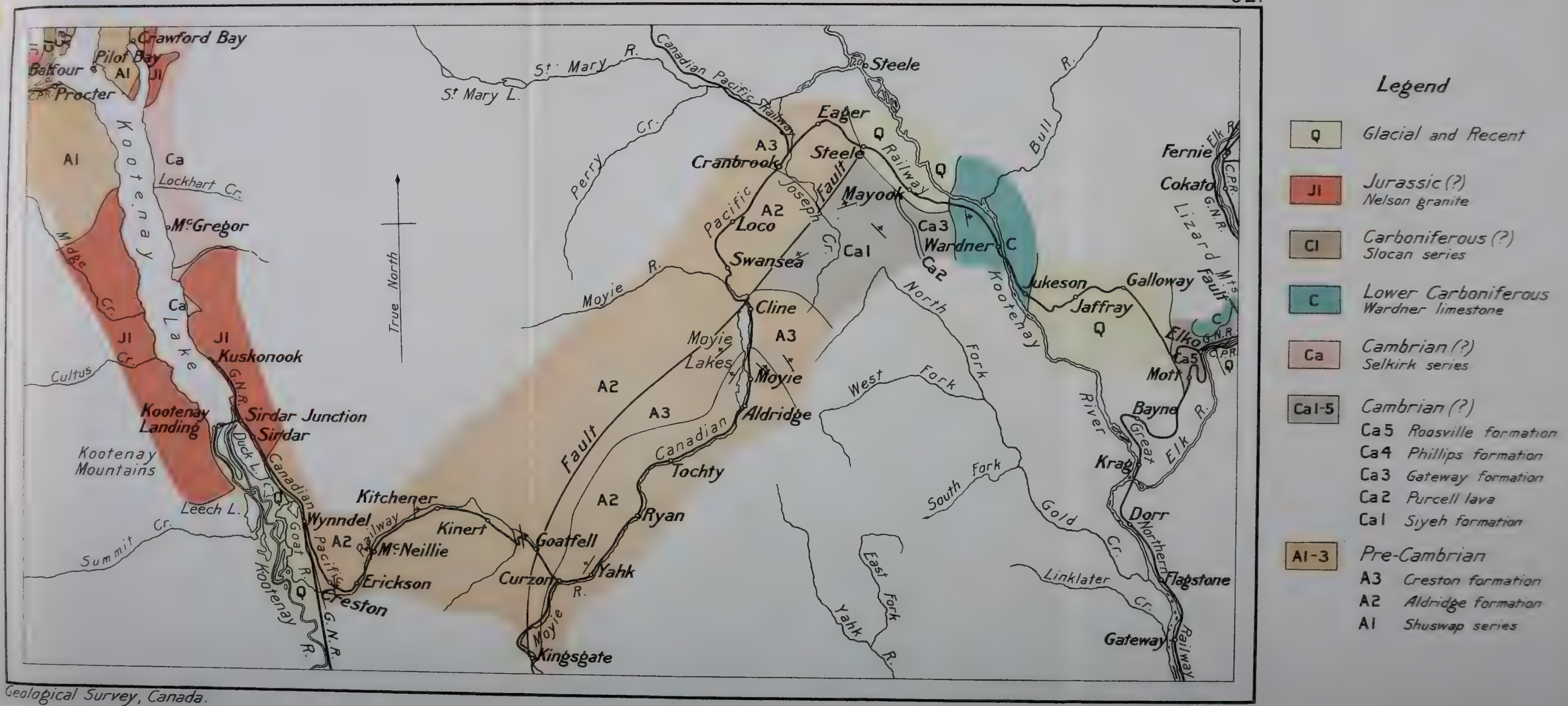
Kootenay Landing—Altitude 1,727 ft. (524 m.). From here a fine view of the delta to the south can be obtained. This valley separates the Purcell range on the east, from the Selkirk system on the west.

Kootenay Lake—Kootenay lake occupies the Purcell trench which marks the boundary between the Purcell mountains to the east and the Selkirk system to the west. The lake is about 65 miles (104 km.) long with an average width of about two miles (3 km.). The elevation above sea level is about 1,750 feet (523 m.) and the greatest known depth is 450 feet (137 m). The total area is approximately 220 square miles (7,000 hectares).

The lake is almost straight with a general trend a few degrees west of north. The outlet is through the west arm about 30 miles (48 km.) north of Kootenay Landing. The lake is closely bordered by rugged mountains which slope more or less steeply from the shore and in many cases are fronted with cliffs. The crest lines average over 6,000 feet (1,828 m.) with occasoinal peaks ranging up to 8,000 feet (2,438 m.).

Sandy and gravelly beaches and deltas are found opposite the mouths of the entering streams; elsewhere the shore is rock-bound.

The southern 30 miles (48 km.) of the lake is for the most part eroded in the granitic rocks of the Nelson batholith with the exception of a portion of the east shore between Columbia point and Crawford bay which is underlain by sediments of the Selkirk series striking with the trend of the shore line and showing subordinate strike ridges. Also on the west shore at Proctor and continuing south for 10 miles (16 km.) the Shuswap series is developed, the beds striking northeast and dipping northwest. At Proctor the Shuswap series outcrops on both sides of the lake.



Geological Survey, Canada.

Route map between **Elko** and **Procter**

Miles: 10 5 0 10 20

Kilometres: 10 5 0 10 20 30

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WEST KOOTENAY AND BOUNDARY DISTRICTS

BY

O. E. LeRoy.

Geology of the Region between Proctor and Midway.

INTRODUCTION.

The area embraced by the route map from Proctor to Midway [**1**] lies within the Selkirk and Columbia Mountain systems of the Western Cordillera. The Selkirk system has the Purcell trench (Kootenay lake) as its eastern boundary and the Selkirk valley (Columbia river) as its western. The Columbia system extends westwards from the latter trench to Kettle river [**2**]. The greater part of the area consists of rugged mountainous country which is often alpine in character, tabular reliefs being isolated and comparatively rare. The main ridges trend in various directions and range in elevation from 5,000 to over 6,000 feet (1,524 to 2,133 m.) with peaks from 1,000 to 3,000 feet (304 to 914 m.) higher.

In the Columbia system west of the subordinate trench occupied in part by Christina lake, the mountains are of

a more subdued type characterized by rounded ridges and dome-shaped summits, the average elevation rarely exceeding 5,000 feet (1,524 m). The principal valleys constitute a well marked longitudinal and transverse system which serves as boundaries of subdivisions on mountain groups. The most striking features of the Selkirk system are the Purcell trench occupied by Kootenay lake and the Selkirk valley occupied by Columbia river, and the connecting transverse valley occupied by the West arm of Kootenay lake and its westward extension, Kootenay river.

GENERAL GEOLOGY.

The main geological divisions are briefly classified in the following table of formations. The smaller geological units, however, have been omitted on the route maps owing the scale of publication.

Table of Formations.

Quaternary	Glacial and Recent.	
Tertiary	Miocene	Midway volcanic group.
	Oligocene	Kettle river formation, Rossland alkali granite and syenite, Valhalla granite.
Mesozoic	Jurassic ?	Nelson batholith. (Rocks range from granite to gabbro). Monzonite.
Palæozoic	Carboniferous and Post-Carboniferous	Rossland group. Rocks largely of igneous origin. It includes the Brooklyn and Rawhide formations and the Knob Hill group at Phoenix; the Mount Roberts formation and the augite porphyrite series at Rossland.
	Carboniferous (?)	Pend d'Oreille group. (Metamorphosed sediments in great part). Slocan series. (Slates, argillaceous limestones and quartzites).
	Cambrian (?)	Selkirk series.
Pre-Cambrian		Shuswap series. (Schists, orthogneisses, etc.).

PRE-CAMBRIAN.

The Shuswap series is the oldest known terrane in British Columbia. It consists of a series of gneisses,

crystalline schists, quartzites, crystalline limestones and dolomites with intercalated sills of quartz porphyry, granite, diorite, etc., which are also more or less foliated. According to Dawson and Daly the present condition of the rock series has been effected by static regional metamorphism, the stress directing the crystallization being induced by deep burial and dead weight.

In the vicinity of Proctor on the north side of the west arm the strike of the series is approximately parallel to the shore of Kootenay lake, the prevailing dip being to the west. The west shore of Kootenay lake is the only point in the area where the Shuswap rocks are in direct contact with the immediately succeeding series.

CAMBRIAN (?).

Selkirk series—The formations grouped under the Selkirk series, which has been tentatively referred to the Cambrian, have not been studied in sufficient detail to admit of the series being definitely placed in the geological scale. It is probable, however, that part of the series is Pre-Cambrian. The rocks consist of mica - chlorite - and other schists, bedded quartzites, dolomites and conglomerates, and schistose rocks of distinctly igneous origin. Stocks and masses of diorite, and serpentine, dykes and sheets of acid and basic intrusives and various types of pyroclastic rocks are also included. The structure is distinct in the areas where sedimentaries predominate but much obscured where the rocks are more massive and of igneous origin.

In this area the series overlies the Shuswap and forms a narrow band paralleling the latter along the west shore of Kootenay lake.

CARBONIFEROUS (?)

Slocan series—The Slocan series is tentatively referred to the Carboniferous. It consists of a thick series of argillaceous quartzite, sandstones, argillites more or less carbonaceous, and argillaceous limestones. The rocks are folded and probably much faulted. This can only be inferred from the frequent crush zones as the rocks usually are too uniform in composition to show pronounced contrasts on each side of a fault plane. Along

the margins of batholithic and stock-like intrusions the rocks have been altered to hornstone, andalusite schist, crystalline limestone and lime-silicate rocks rich in garnet. The contact with the Selkirk series is marked by a close fold or fault. Small infolds of the Slocan rocks are of common occurrence in the Selkirk series near the contact. The Slocan series is noted chiefly for the system of fissure veins which contain the important deposits of si ver-lead and zinc ores (see p. 97).

Pend d'Oreille group—The Pend d'Oreille group consists of andalusite, quartz and biotite schists, quartzites and crystalline limestones. Though not definitely correlated with the Slocan series the similarity in lithological character would favour the view that the Pend d'Oreille group is a more metamorphosed phase of the Slocan series.

CARBONIFEROUS AND POST-CARBONIFEROUS.

Rossland group—The Rossland group is a complex composed largely of rocks of igneous origin with a minor development of sedimentaries. The igneous rocks are represented by porphyrites, andesites, diabases, agglomerates and tuffs with their schistose equivalents while the sedimentary rocks are mainly slates and limestones, the latter holding obscure Carboniferous fossils. Along the International Boundary there is an apparent unconformity between this group and the Pend d'Oreille group. The group originally included the Mount Roberts formation and the augite porphyrite series at Rossland (p. 85) and the Rawhide and Brooklyn formations and Knob Hill group at Phoenix (p. 75).

Monzonite—The monzonites are dark grey to greenish-grey porphyritic or granular mottled rocks, their period of intrusion ranging from Mesozoic to early Tertiary. The intrusions have the form of plugs, dykes and irregular masses approaching batholiths in importance.

JURASSIC (?)

Nelson batholith—The Nelson granodiorite batholith has a very extensive development in West Kootenay district and also extends into East Kootenay and the Boundary district. The granodiorite is intrusive in all

the older formations from Shuswap to the Rossland group. The main mass centres in the vicinity of Nelson while in the outlying areas the batholith is represented by smaller masses and cupola stocks. The contact phenomena are very pronounced for varying widths along the border of intruded rocks, while in the granodiorite the field evidence at many points is excellent in illustration of overhead stoping, differentiation, and absorption of roof and wall rock. The rocks composing it vary from light grey granite to dark grey quartz diorite and even more basic types. A typical and widespread differentiate is a granite porphyry consisting of stout phenocrysts of feldspar 1 to 2 inches (2·5 to 5 cm.) in length in a rather coarse grained base.

An analysis of a specimen from Kokanee mountain by Dr. F. Dittrich of Heidelberg showed the following composition:—

SiO_2 66·46, TiO_2 0·27, Al_2O_3 15·34, Fe_2O_3 1·68, FeO 1·83, CaO 3·43, MgO 1·11, Na_2O 4·86, K_2O 4·58, H_2O 0·29, P_2O_5 0·08—Total 99.93·

The Valhalla granite is closely associated with the rocks composing the Nelson batholith and occurs as large and small intrusive masses within the area underlain by the Nelson batholith. It is probably early Tertiary in age. The rock is a quartzose medium grained light-coloured hornblende or biotite granite with local granodiorite facies.

TERTIARY.

Rossland alkali granitic rocks—In this group are included several varieties of intrusive rocks ranging in composition from alkali granite to essexite, the most common type being pulaskite. These intrusives range in importance from dykes and sills to bodies of batholithic proportions, the latter type being well developed along Lower Arrow lake south of Edgewood (see p. 94).

OLIGOCENE.

Kettle River formation—The Kettle River formation was laid down during the Oligocene period probably in a broad syncline prepared in early Tertiary. The formation is now represented west of Christina lake by

a series of isolated and somewhat widely separated erosion remnants (see map of Boundary district), the individual units being two small to permit of their delineation on the route map. The rocks composing the formation consists of conglomerates, sandstones and shales with some intercalated tuffs which were laid down in lake and river basins bottomed in most cases by rocks of Palæozoic age. Some of the shales are carbonaceous and contain plant remains and in a few instances thin seams of lignite.

OLIGOCENE AND MIOCENE.

Midway Volcanic group [3]—The Midway Volcanic group consists of a series of lava flows of two distinct volcanic epochs in the Boundary district. The lavas naturally arrange themselves in three groups, the oldest consisting of olivine basalt and augite andesite, the middle group composed of a variety of andesites, and the youngest represented by alkaline trachyte. The oldest and middle groups are referred by Daly to the Oligocene, and the youngest possibly to the Miocene or at any rate after the Kettle River sediments have suffered deformation and erosion.

The lava groups have corresponding intrusive equivalents ranging from augite gabbro to pulaskite porphyry which cut them as dykes, sills and stocks. These volcanics occur in small isolated areas in the eastern part of the Boundary district west of Christina lake, In the vicinity of Midway however, the lavas are extensively developed both to the north and west.

Subsequent warping accompanied by faulting has affected both the Midway Volcanic group and the Kettle River formation.

QUATERNARY.

The Cordilleran ice sheet covered the whole of southern British Columbia with the exception of some of the higher peaks. In this area the general trend of ice movement was S. 30° E. The ridges were smoothed into rounded and flowing forms, the main valleys were deepened with consequent truncation of spurs and the development of hanging valleys. With the breaking up of the ice sheet

into valley glaciers the smooth and rounded contour of ridge and hill was destroyed by the roughening effect of the latter glaciers which has given the present characteristic alpine topography in areas above the level of the 5,000 foot (1,524 m.) contour. In the vicinity of Nelson well marked glacial striae and groovings have been noted at an elevation of 6,600 feet (2,000 m.) and erratics at 7,184 feet (2,188 m.) above sea level. The slopes are covered with a mantle of varying thickness of drift more or less modified and of "wash". The main valleys are usually flanked by a series of terraces.

ANNOTATED GUIDE.

(PROCTOR TO CASTLEGAR).

Miles and Kilometres.

Proctor—At the entrance to the west arm of Kootenay lake and for about three miles (4·8 km.) to the west, the valley is eroded in rocks of the Slocan, Selkirk and Shuswap series. Westward to and beyond Nelson the valley lies within the area underlain by the granitic rocks of the Nelson batholith. The west arm preserves its lake-like characteristics as far as Nelson though at several points moderate currents have developed due to the encroachment of delta deposits. Just west of Nelson the arm is blocked by boulder drift and a small rapid is developed, marking the continuation of Kootenay river. The rocky bed of the river is but little below the present level of erosion in contradistinction to the bed of the west arm which for the most part has a depth comparable to the main part of Kootenay lake.

0 m. 0 km. **Nelson**—Altitude, 1,769 ft. (539 m.). The city of Nelson is situated on the delta of Cottonwood creek which flows into the west arm about 22 miles (35·4 km.) west of the main body of Kootenay lake. The city owes its existence primarily to the mining activity in the later 80's and for some years its growth depended wholly on the mining industry. At present, mining, lumbering, manufacturing and fruit ranching are the chief industries and the city is also the

View showing West arm of Kootenay lake, with the towns of Nelson and Fairview, and the deltas of Cottonwood and Anderson creeks, Kokanee peak (9,400 ft.) and glacier (9,060 ft.) in the distance.

Miles and Kilometres.

main distributing centre for the Kootenay and Boundary districts. The city is underlain by granitic rocks of the Nelson batholith near the northern edge of an area of the rocks of the Rossland group [**4**]. The latter also appear in small isolated patches throughout the main area underlain by the batholith. The ore deposits are all later than the intrusion of the granodiorite batholith (Jurassic?) and younger than the last evidences of igneous activity which form a system of lamprophyric dykes cutting and faulting the ore bodies. The country in the vicinity of Nelson is rather widely mineralized, the principal deposits being gold-silver, silver-copper, silver-lead and copper-gold-silver. The chief mines working at present are the Granite-Poorman (gold), Silver King (silver-copper), Molly Gibson (silver-lead), and the Eureka and Queen Victoria (copper-gold-silver). The total production of the mining division to the end of 1911 amounts to rather more than $10,700,000 in value.

10·8 m.
17 km.

Bonnington Falls—Alt., 1,658 ft. (505 m). Four miles (6·4 km.) west of Nelson the railway crosses to the north side of Kootenay river. The Kootenay from Granite to Castlegar (22 miles or 35 km.), where it joins the Columbia, has a fall of 335 feet (102 m.), and is characterized by swift-flowing reaches, falls and rapids. The most important falls are at Bonnington, where it is estimated that under a 40-foot head 267,000 H.P. can be developed at low water. At present there are two plants, the West Kootenay Power and Light Company with 20,000 H.P. developed, and the City of Nelson power plant developing 2,350 H.P. The former company supplies power and light to various points in West Kootenay and the Boundary districts, particularly to the mining and metallurgical centres at Trail, Rossland, Grand Forks, Phoenix and Greenwood.

12 m.
19 km.

South Slocan—Alt., 1,637 ft. (499 m.). South Slocan is the junction point from which a branch railway runs to Slocan city and Slocan lake in

Miles and Kilometres.

Slocan district, which is noted for its silver-lead and zinc deposits. (See p. 96).

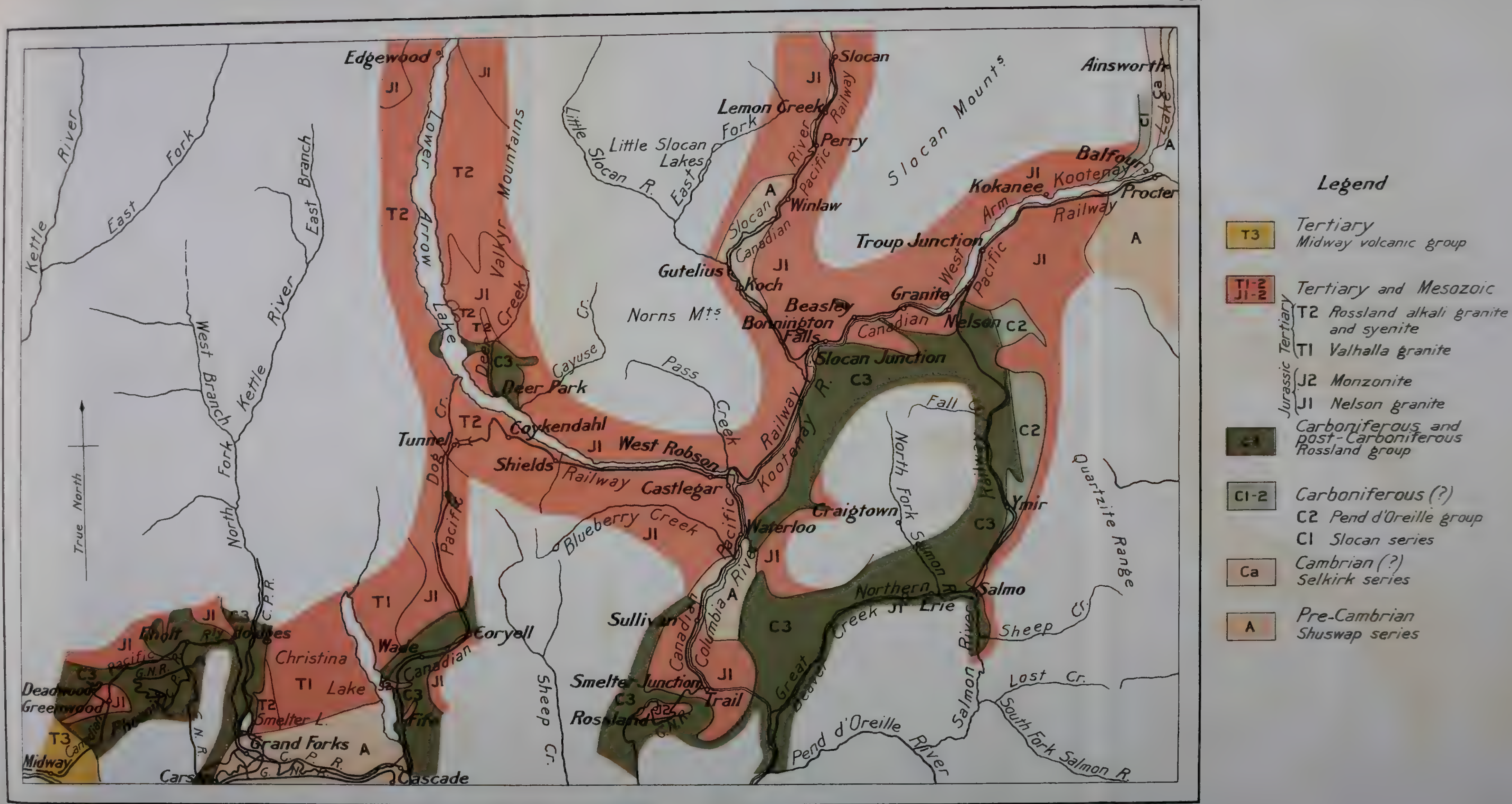
26 m. 40 km. **Castlegar**—Alt., 1,418 ft. (432 m). From South Slocan the railway runs west of south, following the right bank of Kootenay river. Castlegar marks the junction of the Columbia and Kootenay rivers which after uniting, flow southwards as the Columbia.

The Columbia rises in Upper Columbia lake and flows north. The Kootenay, rising just east of the westernmost outer range of the Rockies, enters the same valley nearly abreast of the above lake, the distance between the two being about one and a half miles (2·4 km). The Columbia flows north for about 170 miles (274 km.) to the great bend, then southwards through Upper and Lower Arrow lakes to Castlegar, where it is joined by the Kootenay. The latter, after leaving the source of the Columbia, flows southwards into the United States for about 130 miles (209 km). It then takes a westward course turning to the north and empties into Kootenay lake, emerging again as a river just west of Nelson and joining the Columbia at Castlegar.

ANNOTATED GUIDE (Castlegar to Midway).

At Castlegar the railway crosses the Columbia and follows the south shore of the river and Lower Arrow lake. The rock types exposed are nearly all members of the Nelson batholith with inclusions of the Rossland group.

39 m. 62 km. **Shields**—Alt. 2025 ft. (617 m.). The railway gradually ascends in order to reach the divide separating Lower Arrow lake and Christina lake. Shields approximately marks the contact between the rocks of the Nelson batholith and the Rossland alkali-granitic rocks intrusive into the former. From the spur just west of Shields an excellent view is obtained of that portion of the Columbia valley between Robson and Deer Park.



Geological Survey, Canada.

Route map between **Procter** and **Midway**

Miles 10 5 0 10 20

Kilometres 10 5 0 10 20 30 40

Miles and Kilometres.

50 m. 80 km. **Tunnel**—Alt. 3208 ft. (978 m.). The main ridge is tunnelled through near the western contact of the Rossland alkali granitic intrusion and that of the Nelson batholith. The tunnel is about 0·4 miles (0·6 km.) in length. Its east portal is marked by stratified clays. Four miles (6·4 km.) south of the tunnel is the Big Turtle filled by hydraulicking.

58 m. 93 km. **Farron**—Alt. 3985 ft. (1214 m.). From about a mile (1·6 km.) southwest of the tunnel to a point about three miles (4·8 km.) north of Coryell, the railway traverses the granitic rocks of the Nelson batholith. The cuts show many inclusions of the igneous rocks of the Rossland group and of crystalline limestones. Southwards to the crossing of Kettle river the rocks of the Rossland group are almost continuously developed, associated with minor intrusions of monzonite. The limestone member is well developed in lens-like masses.

77 m. 124 km. **Fife**—Alt. 1978 ft. (603 m.). Near Fife the limestone is quarried and shipped to Trail smelter where it is used for flux.

To the north and south of Fife an excellent view is obtained of the trench occupied by Christina lake (elevation 1450 ft. or 442 m.) and Kettle river. From Kettle river crossing to Grand Forks, the railway follows the river valley, which is underlain by foliated rocks tentatively referred to the Shuswap series.

95 m. 153 km. **Grand Forks**—Alt. 1746 ft. (532 m.). Grand Forks [**5**] is situated at the junction of Kettle river and its main tributary, the North Fork. The valley is bordered by a series of terraces, and the river meanders in broad curves through the relatively wide bottom.

The smelter of the Granby Consolidated Smelting and Power Company is situated on the North Fork about one mile (1·6 km.) from the centre of the city.

109 m. 175 km. **Eholt**—Alt. 3096 ft. (944 m.). From Grand Forks the railway follows the west side of the valley of the North Fork and an excellent

Miles and Kilometres.

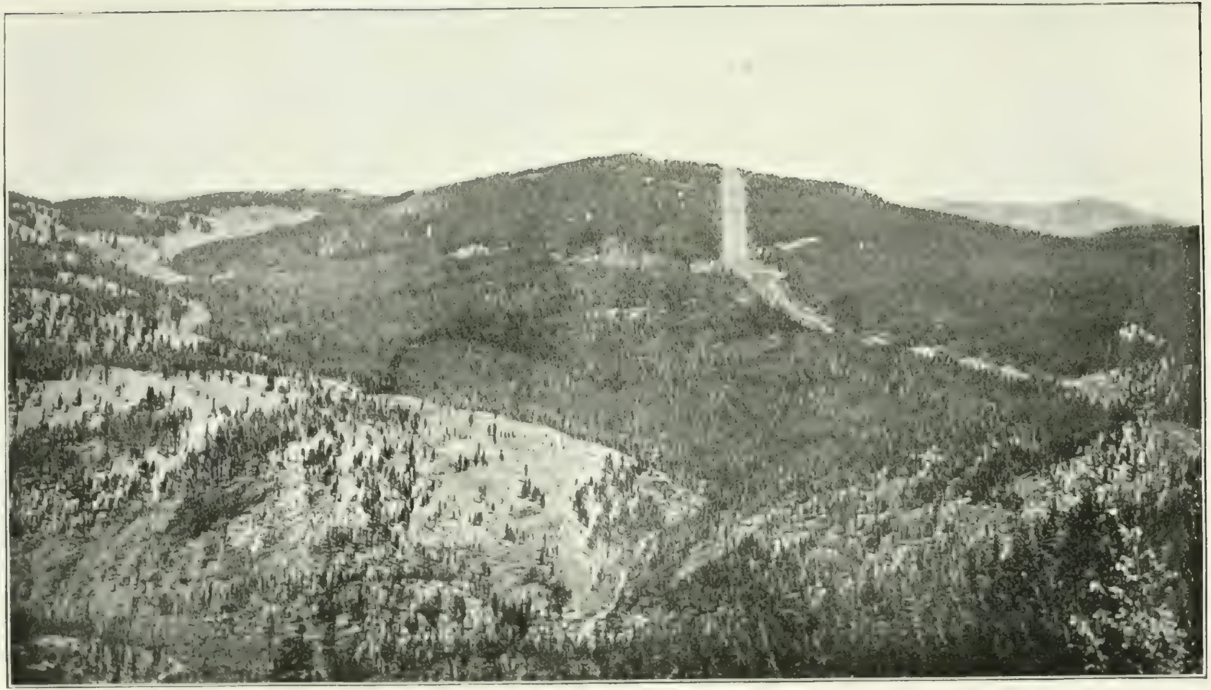
view is obtained of the U-shaped flat-floored valley. The area traversed between Grand Forks and Phoenix, via Eholt, is underlain by several members of the Rossland group, including limestone. Eholt is the junction point from which a branch line goes to Phoenix. About three miles (4·8 km.) south of Eholt the railway crosses the copper and magnetite deposits of the Oro Denoro and Emma mines, the origin of which is similar to those at Phoenix.

PHOENIX [**6**].

Introduction.

The production of the Boundary district (including the Osoyoos Mining Division) from 1896 to the end of 1912 amounts to 13,744, 338 tons of ore, containing 938,125 ounces of gold, 5,035,953 ounces of silver, and 334,874,378 pounds of copper, having a gross value of $73,312,913. Approximately 60 per cent of the tonnage was furnished by the mines at Phoenix.

The copper-bearing portion of the Boundary district occupies an area of about 25 square miles (62 sq. km.) and includes the important centres of Phoenix, Greenwood (Deadwood) and Summit. It was in 1891, following the discoveries at Rossland, that prospecting was actively carried on in the three above named camps. In that year most of the ground subsequently proved to be productive was staked. The low grade character of the ore proved a great disappointment which was partially offset by the discovery that the ore was almost self fluxing. The field, however, was open only to large companies with financial resources beyond those of the average individual. The two companies at present operating were early in the field; the Granby Consolidated Mining, Smelting and Power Company confining its attention to Phoenix, and the British Columbia Copper Company operating at Deadwood and Summit. The smelter of the former was built at Grand Forks and the first furnace blown in in 1900. Its capacity has been increased from 1200 tons to between 4000 and 4500 tons per day. The latter company commenced smelting at Greenwood in 1901. The present capacity of its furnaces is about 2600 tons per day.



Typical view of Midway mountains, with Greenwood in the foreground and Phoenix in the basin at the head of Twin creek.

The city of Phoenix is 118·5 miles (190 km.) distant by rail from Nelson, and is 4,600 feet (1402 m.) above sea level. The city lies well within the Midway mountains, a subordinate group of the Columbia system characterized by comparatively low summits which show a uniformity of crest line and they are below the limits of intense alpine erosion.

General Geology.

The oldest rocks are of Palæozoic age and correspond largely to the Rossland group, a complex of igneous rocks with minor developments of sedimentary types. The structure is very complicated and there is an entire absence of broad or continuous folds. The Mesozoic batholithic intrusives and the consequent crustal disturbances have added to the obscurity of formational relationships. After the Laramide revolution the early Tertiary was characterized by disorganized drainage and vigorous erosion with sedimentation (Oligocene) in the broader basins and with contemporaneous volcanic activity accompanied by later warping and faulting. The later Oligocene and Miocene lava flows were widespread. They were followed by a period of erosion which developed a mature topography with local base levelling followed by uplift. The whole area was further modified by the Cordilleran ice sheet.

Table of Formations.

Quaternary.	Glacial and Recent.	Clay, sand, gravel.
Tertiary......	Miocene...........	Pulaskite porphyry, Augite porphyrite, Midway volcanic group represented at Phoenix by flows of trachyte.
	Oligocene..........	Kettle river formation, Conglomerate, sandstone, shale.
Mesozoic......	Jurassic (?)........	Batholithic intrusion, represented at Phoenix by augite syenite and syenite porphyry dykes.
Palæozoic	Carboniferous ?.....	Attwood series. Rawhide formation. Brooklyn formation. Knob Hill group.

Carboniferous?

The rocks tentatively grouped under Carboniferous correspond to those of the Rossland group, subdivided at Phoenix into the Knob Hill group and the Attwood series. Their broad structural relation suggests a synclinal fold.

Knob Hill Group—The Knob Hill group consists of a complex of highly altered rocks of igneous origin with minor developments of sediments. The more common types are massive breccias, tuffs and cherts with small lens-like masses of argillite and limestone. Hornblende and augite porphyrites, as dykes and sheets, are less common than in the Rossland area. The most marked feature is the widespread silicification and extensive development of cherty types. The absence of definite structural features prevents an estimate being made of the thickness of the group, but it is known to have a vertical depth of over 1,000 feet (304·8 m.).

Attwood series. Brooklyn formation—The Brooklyn formation overlies the Knob Hill group without any marked stratigraphical break. Originally consisting of limestones with some tuffs and calcareous argillites, the formation now admits of a threefold division based on lithology. The lower zone consists of jasperoids and the upper is composed essentially of lime-silicates (garnet, epidote, etc.), while the limestone forms residual lens-like bodies in both of the above zones.

The jasperoids are derived from limestone tuffs and fine breccias by replacement along planes of bedding, jointing and fracture. They consist of oval, rounded, oblong and subangular pebble-like individuals of crypto-crystalline quartz varying in size from almost microscopic grains to those six inches (15 cm.) or more in diameter. The color is usually dull white or grey, but pink, brown and bright red (jasper) types are locally prevalent. The matrix consists of calcite and shreds of chlorite. Pyrite is usually present. The jasperoids originating from coarse tuffs or breccias contain fragments of different types of volcanic rocks. All transitions are to be seen in the field from the normal limestone to jasperoid in which the original limestone has entirely disappeared.

The zone of lime-silicates is of contact metamorphic origin and consists essentially of garnet and epidote with calcite, quartz and chlorite and trifling amounts of actinolite and zoisite. Irregular lenses and masses of crystalline limestone are also included in the zone and represent unreplaced portions of the original calcareous formation. The zone or rather zones occupy basin-like depressions in the jasperoids. They are for the most part economically important and contain the large bodies of low grade copper ore which have been deposited in certain favourable areas usually along the edge or base of the contact zone.

Jurassic ?

The granodiorite batholith so extensively developed throughout the Boundary district and which probably underlies Phoenix at no great depth, is represented at Phoenix by a small stock of augite syenite and two dykes of syenite porphyry which cut the Brooklyn formation.

Tertiary.

Oligocene. Kettle River formation.—An isolated area of this formation occurs at Phoenix overlying unconformably the Brooklyn formation and Knob Hill group. The exposure is about one mile (1·6 km.) long and from 40 to 960 feet (12 to 292 m.) wide and 260 feet (80 m.) thick. The formation here consists of conglomerate, coarse and fine feldspathic sandstone, and cherty carbonaceous shales and light grey indurated silts. The strike is northerly and the dips are prevailingly eastward at angles varying from 10 to 60 degrees. The formation has suffered from warping, tilting and erosion before being covered by the Miocene lavas (see section p. 80).

Miocene. Midway Volcanic group.—An erosion remnant of one of the younger lava members of the Midway Volcanic group overlies the Kettle River formation and Knob Hill group. The exposure is a little over a mile (1·6 km.) long and from 1,100 to 2,000 feet (335 to 609 m.) wide. The thickness varies from a few inches (cm.) to about 300 feet (91 m). The rock, though varying in texture from porphyritic to amygdaloidal, is an augite trachyte composed of phenocrysts of orthoclase, soda-orthoclase, andesine, augite and biotite in a base of the same minerals with

additional magnetite and apatite and secondary chlorite and calcite. An analysis by M. F. Connor of the Mines Branch gave the following:—SiO_2 52·64, Al_2O_3 20·69, Fe_2O_3 2·54, FeO 1·82, MgO 1·61, CaO 3·93, Na_2O 4·84 K_2O 5·99, H_2O+2·23, H_2O– 0·28, CO_2 0·75, TiO_2 0·64, P_2O_5 0·41, MnO 0·07, SrO 0·21, BaO 0·60=99·25.

According to the quantitative classification the rock falls in class persalane, order russare, rang viezzenare, subrang, procenose.

The augite trachyte lava and all the older rocks are cut by sills, dykes and stocks of augite porphyrite and pulaskite porphyry, the latter being the younger. The augite porphyrite is dark grey in colour with a porphyritic texture approaching granitoid. It consists of dark grey tabular phenocrysts of orthoclase and plagioclase—the latter being between andesine and labradorite,—augite, brown hornblende and biotite in a base which is largely feldspathic. Apatite and magnetite are also present as well as a small amount of quartz.

The pulaskite porphyry is light grey, weathering to pink or pale red, with characteristic rosette-like clusters of white feldspars in a fine-grained highly feldspathic base.

The phenocrysts are soda-orthoclase, oligoclase and acid andesine. The larger individuals are surrounded by a zonal crust of clear orthoclase. The augite and biotite individuals are largely altered to granular carbonates with chlorite and magnetite. Hornblende, quartz, apatite and magnetite are present as accessories.

Analyses of the augite porphyrite and pulaskite porphyry were made by M.F. Connor of the Mines Branch. The former is under Column I the latter under II.

	I.	II.
SiO_2	55·90	57·32
Al_2O_3	15·52	17·27
Fe_2O_3	1·22	1·62
FeO	5·22	3·94
MgO	4·70	2·68
CaO	5·79	4·24
Na_2O	2·89	4·52
K_2O	4·45	5·96
H_2O+	1·40	0·47
H_2O–	0·60	0·08
CO_2	0·14	....

TiO_2	0·90	0·88
P_2O_5	0·46	0·51
MnO	0·08	0·09
SrO	0·09	0·06
BaO		0·24
	99·36	99·88

I. Class dosalane, order germanare, rang andase, subrang shoshonose.

II. Class dosalane, order germanare, rang monzonase, subrang monzonose.

Glacial and Recent.

The area about Phoenix is free from any thick or continuous mantle of drift. Cuttings in the valley of Twin creek show rudely stratified sands, clays and gravels. The surrounding ridges are glaciated to their crests, the striae having a direction of S. 26° E.

ORE DEPOSITS.

The copper deposits occur at intervals along the edges of the zones of contact metamorphism and also at the base of the zone or in some non-outcropping intermediate position.

The zone in which the principal deposits occur is horseshoe-shaped. The west limb is 3,200 feet (975 m.) long and 1,000 feet (304 m.) wide, while the east limb is 2,250 feet (686 m.) long and from 350 to 1,000 feet (107 to 304 m.) wide. The thickness varies from one foot (30 cm.) or so to 350 (106 m.). The floor is jasperoid or in places the siliceous rocks of the Knob Hill group.

Knob Hill-Ironsides mine—The ore body of the above mine owned by the Granby Consolidated, is the largest and most typical of the camp. The ore body is composite in character and consists of two lenses which coalesce about their central portions. Along the outcrop these appear as distinct ore bodies separated by a varying thickness of the lime-silicate gangue rock (see section). The western lens is at least 2,500 feet (762 m.) long, from 370 to over 900 feet (113

Portion of glory hole, Knob Hill and Ironsides mine, Phoenix.

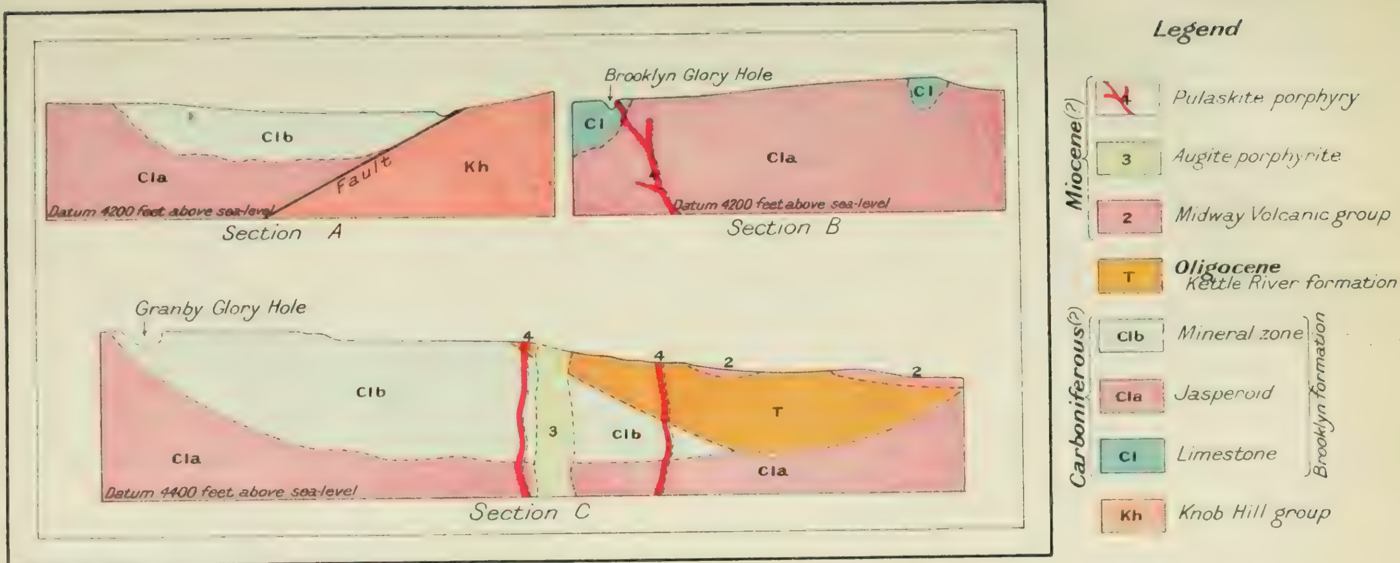
to 274 m.) wide, and from 40 to 125 feet (12 to 38 m.) thick. The eastern lens is apparently shorter but approaches the magnitude of the other in width and thickness. The general strike along the outcrop is about N. 10° E. with dips to the east ranging from 45 to 60 degrees. The dip flattens with depth and on the lower levels averages from 15 to 30 degrees. The general pitch of the ore bodies is about 18 degrees to the northeast. The vertical range from the south end of the main "glory hole" to the lowest working levels is 675 feet (206 m.). The structural footwall is the jasperoid zone of the Brooklyn formation, and in places, the siliceous rocks of the Knob Hill group. The hanging wall is a purely commercial one and the ore either grades insensibly into barren gangue or terminates sharply against a gouge-filled fissure. The ore bodies and adjacent rocks are traversed by an intricate system of fissures which run in all directions and dip at all angles. They have had a most important influence on ore deposition as they formed channels for the ore-bearing solutions which permitted a uniform distribution of their metallic contents. In many cases the ore adjacent to these fissures is of noticeably higher grade. Some of the fissures have been subsequently filled with banded quartz, calcite and chalcopyrite.

The only displacement noted is along one of the major fissures which faulted the ore body with a throw varying from zero to 120 feet (36 m.) along a dip of 55 degrees to the west. (See section).

The ore is mainly massive with local banded areas. It consists of chalcopyrite, which with pyrite and hematite is finely and uniformly distributed through a gangue composed almost exclusively of garnet, epidote, quartz, calcite and chlorite. The pyrite occurs in grains, crystals and streaks, while the hematite (specularite) occurs in platy aggregates. Magnetite occurs in masses and irregular lenses at intervals through the ore bodies but it is relatively unimportant. The average content of the ore is: copper 1·25 per cent; gold 0·04 ounces and silver 0·3 ounce per ton. Along the outcrop the ore has been leached out in part but has produced no noticeable secondary enrichment at lower levels.

The zone of contact metamorphism and the development of lime-silicates is believed to have been the result of metasomatic replacement of limestone by solutions

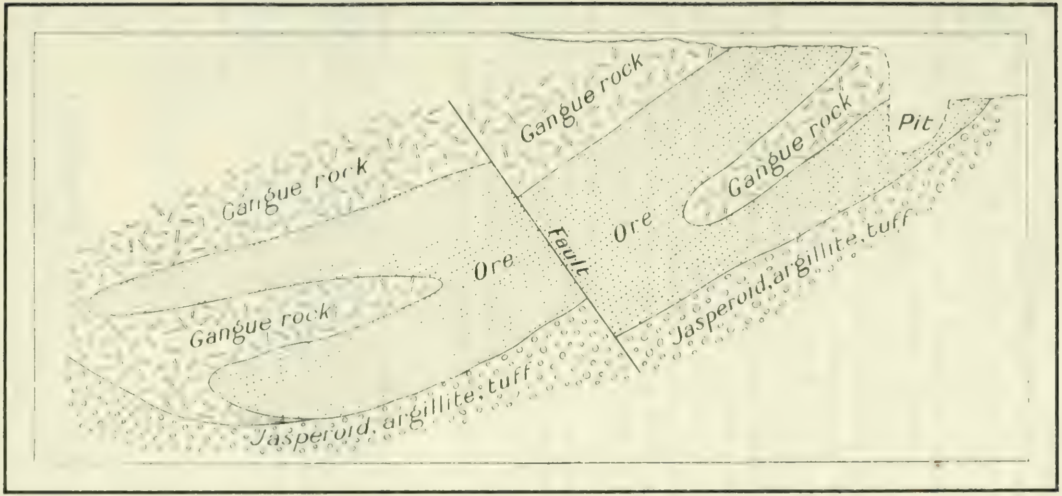
C2.



Geological Survey, Canada.

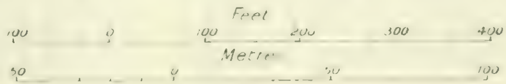
Phœnix—Structural sections illustrating the relations of the mineralized zone and the country rocks

C2.



Geological Survey, Canada

Section across ore-body. Knob Hill-Ironside Mine



above the critical temperature carrying ferric iron, alumina and silica and consisting mainly of water gas strongly ionized. Epidote and garnet, etc., were formed, and the magnetite was probably formed contemporaneously with them. When the formation of the above was well advanced the character of the solutions changed somewhat and chalcopyrite, pyrite and hematite were deposited in and along the numerous minute fissures and cavities in the lime-silicates. Calcite and quartz were the last to deposit and completely filled the remaining minute spaces. In the absence of any direct evidence, as there are no large bodies of igneous plutonic rock in contact with or adjacent to the zone of contact metamorphism at present, it is suggested that these zones were overlain by more or less irregular and thick sheets of granitic rock and that these were the cause of the metamorphism of the limestone and the source of the mineral bearing solutions. The circulation would thus be descending and laterally and would account for the ore bodies terminating abruptly at comparatively shallow depths either against jasperoid or crystalline limestone. The age of the deposit is referred to post-Jurassic or the period immediately following the intrusions of the granodiorite batholith of the Boundary district. The ore bodies suffered from erosion in the early Tertiary and are overlain unconformably by Oligocene sediments.

Method of Mining.—The ore bodies are mined along their outcrops by large open quarries or "glory holes" and underground by a system of tunnels and shafts. Stoping by the pillar and room method is used entirely below the level of the "glory holes". The development work is based on the information gained by extensive prospecting with diamond drills.

ANNOTATED GUIDE (Phoenix to Midway.)

Miles and Kilometres.

117 m. 188 km. **Greenwood**—Alt. 2 464 ft. (751 m.). Greenwood is situated in the valley of Boundary creek about four miles (6·4 km.) west of Phoenix. The valley at this point is deeply eroded in granodiorite which underlies and surrounds

Miles and
Kilometres.

the town. The British Columbia Copper Company's smelter is situated at Anaconda which joins Greenwood to the south. The Mother Lode mine of the same company is at Deadwood about 2·5 miles (4 km.) northwest of Greenwood. The copper deposits at Deadwood are similar to those at Phoenix.

127 m.
206 km.

Midway—Alt. 1,913 ft. (580 m.). Midway lies well within an area underlain by the lavas of the Midway Volcanic group. The town is situated in the broad bottom lands of the Kettle River valley, flanked by terraces and backed by low rounded and conical hills of lava. Boundary creek flows on bed rock between Greenwood and Midway, and near the junction with the Kettle, it has trenched itself in a box canyon with walls of lava.

ANNOTATED GUIDE (Castlegar to Rossland.)

0 m.
0 km

Castlegar—Between Castlegar and Smelter the bed rock is mainly the granodiorite of the Nelson batholith with the exception of an area of gneisses and schists (Shuswap series) between Blueberry and Sullivan creeks. Along this portion of Columbia valley, the rock is extensively covered by a system of well-defined terraces composed of horizontally bedded sands and sandy clays. To the south of Castlegar, the valley is relatively broad and the bottom lands and terraces support a flourishing fruit industry.

44 m.
71 km.

Smelter—Alt. 1,565 ft. (467 m.). The smelter and lead refinery of the Consolidated Mining and Smelting Company is situated at Smelter. It is the most important metallurgical centre in British Columbia. The gold-copper ores of Rossland and the silver-lead ores of the Slocan are treated here, and in the case of the latter, the final product is refined silver and lead.

Miles and Kilometres.

The town of Trail lies about 200 feet (61 m.) below Smelter at the junction of the Columbia valley and Trail creek.

ROSSLAND [7].

Introduction.

Rossland is situated about six miles (9·6 km.) west of Columbia river and five miles (8 km.) north of the International Boundary. The main avenue of the city is 3,410 feet (1,039 m.) above sea level. The city lies on the slopes of Red and Monte Christo mountains towards the head of Trail creek. The immediate surrounding country is characterized by mountains with rounded peaks and gentle, flowing slopes. The city commands a view of Trail Creek gulch, the Columbia valley 2000 feet (609 m.) below, the Selkirk mountains to the east and the ranges in Northern Idaho and Washington to the south.

The first discovery near Rossland was made on the Dewdney trail in 1887 when the Lily May claim was staked. In 1890 the LeRoi, Centre Star, War Eagle, and other mines were staked on Red mountain, and a small lot of ore was packed out in 1891 and shipped to an American smelter.

The total production from 1894 to 1912 inclusive, according to the Provincial Bureau of Mines, amounts to 4,105,358 tons, containing 1,995,589 ounces of gold, 3,381,421 ounces of silver and 86,608,170 pounds of copper. The gross value is placed at $55,100,259.

The principal mines at present are the LeRoi, War-Eagle, Centre Star group, owned and operated by the Consolidated Mining and Smelting Company and the LeRoi No. 2 Company. The greatest depth reached is 2,200 feet (670·5 m.) below the surface outcrops, and all ore mined is shipped to Trail for treatment.

GENERAL GEOLOGY.

In 1894 R. G. McConnell made a reconnaissance survey of Rossland for the Geological Survey, and in 1905 and 1906, R. W. Brock, assisted by G. A. Young, made detailed geological maps and mine examinations.

The geology of Rossland centres around a mass of monzonite which is rudely oval in form with the east and west axis about five miles (8 km.) in length. The mass is intrusive into the rocks of the Rossland group, which has been subdivided into a sedimentary and igneous series.

Table of Formations.

Quarternary	Glacial and Recent.	
Tertiary		Pulaskite.
Mesozoic	Post-Jurassic ?	Lamprophyric dykes.
		Serpentine.
		Nelson granodiorite and granite porphyry.
	Jurassic ?	Porphyritic monzonite.
		Diorite porphyrite.
		Monzonite.
	Triassic ?	Volcanic agglomerate.
Palæozoic	Carboniferous	Augite porphyrite.
	(Rossland group).	Mount Roberts formation.

Carboniferous.

Mount Roberts formation—The Mount Roberts formation is developed chiefly in two bands, the broader one lying on the western slopes of Red mountain, while the narrower one lies further to the west, separated by a band of igneous rocks. The formation consists of black slates, in part carbonaceous, with arenaceous and calcareous varieties interbedded with lighter coloured types. There is a frequent interbanding of darker varieties with lighter coloured and more siliceous types some of which are probably of tufaceous origin. Fossils have been collected in one locality and though poorly preserved have been identified as Carboniferous types.

The strike of the formation is northerly with a general dip to the west which steepens on going westward. In the western band the beds are vertical, which is probably due to a fault. The sediments are extensively faulted in an east and west direction with throws varying from a fraction of an inch to several feet. Breccias are common along the contact of the sediments with the granodiorite and porphyrite.

Augite porphyrite.—The augite porphyrite series forms a large part of the area originally mapped as the Rossland volcanic group. It occupies four main areas on the map sheet and is intrusive in the Mount Roberts formation. The structures and textural characteristics of the rock shows that it probably occurred as surface flows and sills. In places the rock is interbanded with fine-grained beds which are probably tuffs. In other places it presents an agglomerate phase of two eruptions. The typical rock is dark grey to greenish black, studded with stout prisms of pyroxene and hornblende imbedded in a dark ground-mass composed chiefly of small laths and grains of labradorite and hornblende. The rock is both massive and sheared and in places is highly altered. An analysis of a type from the War Eagle is as follows:—

SiO_2 50·89, TiO_2 0·80, Al_2O_3 17·00, Fe_2O_3 0·97, FeO 7·60, MnO 0·14, MgO 5·41, CaO 9·82, K_2O 1·31, Na_2O 3·35, H_2O- 0·06, H_2O+1·14, P_2O_5 0·19, S 0·43, CO_2 0·28 = Total 99·39.

Triassic?

The Volcanic agglomerate of probably Triassic age overlies the Mount Roberts formation, apparently conformably. The outcrop is lenticular in form and coincides in strike and vertical dip with the underlying slates. The formation suffered with the Carboniferous in the crustal disturbances of the Jurassic revolution.

The agglomerate is composed of fragmental material including quartz, slate and altered volcanic rocks. The formation also includes some tufaceous beds. There is a rough assortment of the material in certain beds, in which cases the longer axis of the fragments coincide with the general strike of the formation.

Jurassic?

Monzonite.—The monzonite intrusions, in the forms of masses and dykes, are composed of a number of closely related varieties of slightly different ages which underlie about one half of the Rossland map-area. The intrusive masses have an east and west trend and have possibly followed a profound structural break. The structural relations show that the intrusion was subsequent to the

crustal disturbances which tilted and folded the Carboniferous rocks. The main intrusions may at points have originally reached the surface through the Carboniferous sediments and appeared as a volcano or a series of volcanoes. The three principal types in order of age, commencing with the oldest, are monzonite, diorite porphyrite and porphyritic monzonite. In general, the coarser types are younger than the fine-grained ones, and the more feldspathic younger than the basic types.

The normal monzonite shows considerable variation in different parts of the same mass. The rock varies from grey to black in colour, and from granitoid to semi-porphyritic in texture. The coarser types consist of black prisms of pyroxene or secondary hornblende, flakes of brown biotite and a light coloured plagioclase feldspar which is often labradorite. The microscope discloses in addition some alkali feldspar, magnetite and apatite. At times local variations show an almost total disappearance of the feldspar, in which case the bulk of the rock is made up of augite and hornblende. In the finer grained varieties, the granular white feldspathic groundmass is peppered with tiny grains and small prismatic individuals of the dark constituents which gives a characterisitic mottled aspect to the rock.

The following analysis of the monzonite from the 700-foot level of the Le Roi mine was made by the Mines Branch.

SiO_2 54·49, TiO_2 0·70, Al_2O_3 16·51, Fe_2O_3 2·79, FeO 5·20, MnO 0·10, MgO 3·55, CaO 7·06, K_2O 4·36, Na_2O 3·50, H_2O- 0·07, H_2O+ 1·18, P_2O_5 0·20, S 0·23, C O_2 0·24.

Diorite porphyrite.—The diorite porphyrite occurs in oval, dyke-like forms expanding into larger masses. It is probably younger than the normal monzonite but field evidence is not clear on this point. It is cut by dykes of porphyritic monzonite. Mineralogically the rock might be regarded as a phase of the monzonite. It varies from light grey to greenish black. The texture ranges from porphyritic to fine granitoid. The rock consists of phenocrysts of plagioclase feldspar (andesine to acid labradorite), pyroxene and hornblende lying in a groundmass of feldspar, quartz and hornblende, the relative amounts of these constituents fluctuating widely.

Porphyritic monzonite.—The porphyritic monzonite occurs in masses and dyke-like bodies. The outlines of some of the masses suggest in cross-section, pipe-like chambers extending upwards through the Carboniferous rocks and may possibly be portions of old volcanic conduits. In some of its phases the rock resembles types of the coarse monzonite. It is light grey and coarse in grain with large stout prisms of green pyroxene, secondary horblende, countless small rounded hexagonal flakes of brown biotite and abundant andesine feldspar. Another type consists essentially of augite, biotite, an alkali feldspar and acid labradorite.

Post-Jurassic (?)

Nelson granodiorite and granite-porphyry.—The important batholithic intrusion which underlies hundreds of square miles in West Kootenay is represented on the Rossland map by one irregular area and several small masses with related dykes of granite porphyry. The rock is light grey in colour, of uniform grain and is composed of biotite, hornblende, quartz and abundant feldspar chiefly of the plagioclase varieties. The age, as far as the development at Rossland is concerned, can only be referred generally to the period following the Jurassic orogenic movement and prior to the instrusions of pulaskite of the Tertiary.

Serpentine.—The outlines of the serpentine areas in the vicinity of Rossland suggest vertical stocks or necks intruded into the disturbed and highly inclined sediments and porphyrites of the Carboniferous. They appear to occur along the probable line of weakness followed by the intrusions of the monzonite. The exact age of these altered basic plutonics has not been determined beyond the fact that they are older than the Tertiary pulaskite.

Lamprophyric dykes.—The monzonite and granodiorite intrusions were followed by fissuring and dyking on an extensive scale. A general northerly trend is preserved by the dykes although they cross, branch and coalesce in a very intricate manner. The total number of dykes must be very great for in some of the underground workings of the mines they occur on an average of one in

every 25 feet (7·5 m.). The principal varieties are typical minettes, kersantites, vogesites and odonites with many intermediate forms [**1**]. Aplitic dykes also occur which may be complementary to the more basic types.

Tertiary.

Pulaskite.—The pulaskite or alkali syenite occurs in irregular, elliptical and dyke-like masses intrusive in all the older rocks. Some of the present outcropping masses may represent deeply eroded conduits of ancient volcanoes. The normal rock is coarse in grain and pale pink in colour. It is composed essentially of long rectangular feldspars (intergrowths of orthoclase and albite) with biotite and hornblende, though neither of the two latter are abundant. An analysis by Dr. F. Dittrich, Heidelberg, gave the following:—

SiO_2 62·59, TiO_2 0·54, Al_2O_3 17·23, Fe_2O_3 1·51, FeO 2·02, MnO tr., MgO 1·30, CaO 1·99, K_2O 6·74, Na_2O 5·50, P_2O_5 0·11, H_2O 0·30, CO_2 tr., Cl tr., SO_3 tr. = 99·83.

The rock is closely related in every respect to similar intrusions at Phoenix and elsewhere in the Boundary district which are of Miocene age.

ORE DEPOSITS.

There are two mineralized belts in the Rossland camp known as the North and South belts respectively. The North belt is by far the most important. All the rocks except perhaps the later dykes are more or less mineralized, but the large ore bodies are confined mainly to the Carboniferous augite porphyrites and the monzonite, and lie along the northwest border of the large area of monzonite, and near or on the contact of the porphyrites and Mount Roberts formation with the monzonite, granodiorite or granite porphyry. The South belt is underlain mainly by the porphyrites and sediments of Carboniferous age.

In the North belt, the ore deposits occur (a) in fissure veins with or without replacement of the country rock; (b) as lodes in zones of fissuring or shearing, the ore minerals forming a network of veinlets impregnating or replacing in whole or in part the intervening masses of country rock; (c) in irregular impregnations in the country rock. The most important ore bodies found so far have occurred as

indicated under (a) and (b). On the basis of mineral content, the ores may be classified as follows:—

1. Massive pyrrhotite and chalcopyrite ores with some pyrite, occasionally a little arsenopyrite and more rarely magnetite and molybdenite. Galena and blende have been found in a couple of instances. Free gold occurs, but is rarely visible though the proportion runs from 10 to 50 per cent. of the total gold content.

2. Massive coarse grained pyrrhotite with but little copper and gold.

3. Pyrite and marcasite with arsenopyrite in veins with possibly some galena and blende. This type is more characteristic of the South belt, and silver may form an important part of the values.

4. Arsenopyrite, pyrrhotite, pyrite, molybdenite, a little chalcopyrite, bismuthinite, and free gold, as impregnations particularly in and around pegmatitic and aplitic dykes of alkali syenite.

5. Gold bearing quartz veins.

Gangue.

The gangue is chiefly more or less altered country rock with some quartz and locally a little calcite. The country rock may be altered to quartz associated with secondary biotite in bands. Hornblende and chlorite are extensively developed in places. Muscovite, tourmaline, garnet, wollastonite and epidote also occur, and zeolites, chiefly anthophyllite and chabazite, are frequently found.

Ore.

The typical ore consists of more or less altered rock matter with reticulating veins and irregular masses of pyrrhotite, and varying amounts of chalcopyrite with perhaps a little quartz, the sulphides forming from 50 to 65 per cent. of the mass. There are all transitions from the solid sulphides forming massive shoots of ore on the one hand to rock matter or gangue on the other with little apparent mineralization. In cases, however, lightly mineralized gangue may carry high gold values.

The values are largely gold with some copper and a little silver, The gold values do not appear to be dependent on the presence of any one mineral, though in many cases ore rich in chalcopyrite is rich in gold. The pyrrhotite, though gold bearing in some instances, is as a rule very

low grade. An average analysis of the ore from the large producers gives—gold 0·5 oz. per ton, silver 0·3 oz. per ton, copper 0·9 per cent, iron 22 per cent, silica 37 per cent, sulphur 10·8 per cent, lime 4·2 per cent, alumina 14·9 per cent. The ore from near the surface yielded the higher values, but the proportion of free gold does not appear to decrease with depth and high grade ore bodies are still encountered at the lowest developed levels.

Oxidation extends downwards only a few feet from the surface. Secondary enrichment is a minor feature but is found at several points well below the zone of weathering.

Lodes.

The chief lodes or veins have a general easterly trend and northerly dip with an associated fault system trending north and south. The LeRoi-Centre Star main and south lodes and the Josie lode strike about N. 60° E. The LeRoi north vein, the War Eagle vein, and the Centre Star north veins strike N. 70° W., and appear to be offshoots of the main lodes. The dips are to the north ranging from 60° to 70° with local flattenings.

The main LeRoi-Centre Star lode is at least 4,000 feet (1,219 m.) long, with a thickness varying from a mere crack to over 130 feet (39·5 m.) The maximum thickness cannot in many instances be determined owing to the lack of sharply defined walls. Between ore shoots it is sometimes very difficult to trace the lode, particularly where the continuity is broken by faults and dykes.

Ore Shoots.

The ore shoots vary greatly in size and shape, lenticular bodies being the more common. Some are very irregular at one termination especially when forming against a dyke or fault. In such cases the shoot either develops an enormously increased thickness or an L-shaped body is formed by the ore turning sharply and following the plane of the fault or dyke. The pitch varies from vertical to a pronounced easterly or westerly direction dependent upon purely local conditions. In size the shoots vary from a foot (30 cm.) to 130 feet (39·5 m.) in thickness and from 50 to 500 feet (15 to 152 m.) in length. One of

the largest shoots was stoped for 590 feet (152 m.) vertically and averaged 150 feet (32 m.) in length and 56 feet (17 m.) in thickness.

The higher grades of ore are often confined to certain bands in the shoot parallel to the trend of the lode. They either occur in the body of the shoot or on the hanging or foot wall sides. These bands may also change their relative positions suddenly and follow other though parallel planes in the shoots.

The pay ore is sometimes bounded by a fissure or fault plane. More often, however, there is no sharply defined wall, but a transition, usually rapid, from commercial ore to "waste" or nearly barren rock.

The positions of shoots are usually along contacts between the lode and fault planes with impervious walls or dykes. In the case of the dykes the shoots usually form on the under side. When the mashing or shearing of the rock is such that the metal bearing solutions are restricted within zones of reasonable width, other things being equal, the conditions are favorable for the formation of productive ore shoots. The importance of the shoot is ofttimes accentuated by the development of a system of cross fractures emanating from the wall rock.

In the LeRoi, shoots have been found along the contact of the augite porphyrite series and the coarse monzonite and diorite porphyry.

Origin.

Ore deposition began subsequent to the extensive intrusions of alkali syenite and continued up to the period of injection of the last system of dykes. It is thought probable that the deposits are closely related to the alkali syenite.

The deposits were formed through the agency of ascending aqueous mineral-bearing solutions of high temperature which gradually replaced the primary minerals of the country rocks particularly the feldspar.

Certain minerals in small quantities, such as garnet, wollastonite, epidote, amphibole, pyroxene and magnetite suggest an approach to the conditions under which contact metamorphic deposits are formed. Other minerals are characteristic of hydrothermal action such as tourmaline, muscovite, chlorite and zeolites. The paragenesis of the minerals has not been worked out, but pyrrhotite is cut

by veinlets of chalcopyrite though in many cases the two minerals appear to have been contemporaneous.

The values so far have not greatly decreased with depth, though this is not apparent in the production since more lower grade ore can now be mined than formerly because of reduced smelting charges. The evidence though not conclusive, is strongly in favour of almost the entire deposition being due to ascending solutions, though possibly at two or more periods. In the first period, the dyking and faulting phenomena accompanying the formation of the lodes formed barriers which afforded favourable conditions for the precipitation of copper and gold. A favourable area for deposition appears to be the underside of dykes. In the second period, ascending solutions of different composition may have deposited new minerals in the ores or concentrated at successively higher levels, the values of the ore minerals formerly deposited.

If a zone of true secondary enrichment ever existed, it was swept away during the heavy erosion accomplished by the Cordilleran ice sheets.

The success that has attended the vigorous development policy of the operating companies, gives no indication that the productivity of the lodes is near the end, nor even on the wane, but on the other hand, gives every encouragement to the view that ore bodies will be found at much greater depths than the levels now being exploited.

GEOLOGY OF THE REGION BETWEEN CASTLEGAR AND REVELSTOKE.

THE ARROW LAKES.

Between West Robson and Arrowhead there are two pronounced expansions of the Columbia river known as Upper and Lower Arrow lakes, which with the river connections have a total length of about 107 miles (172 km.). The junction of Lower Arrow lake and the Columbia river is about 10 miles (16 km.) west of Castlegar. The lake, whose shape is that of a slightly bent bow with the convex side to the west, has a length of about 51 miles (82 km.) with an average width of about one mile (1·6 km.) tapering at both ends. The low water level is about

1,380 feet (420 m.) above sea level and a sounding taken about the central part of the lake gives a depth of 537 feet (163 m.). The river connection between the lakes is about 20 miles (32 km.) long, the lower 11 miles (17 km.) following a valley parallel to Upper Arrow lake, while the upper nine miles (14 km.) lies in a transverse valley which cuts across the axis of a mountain ranges trending northwest.

Upper Arrow lake has a northerly trend and is about 36 miles (58 km.) long with a prominent northeast arm 10 miles (16 km.) long. The lake has an average width of two miles (3·2 km.) and the low water level is 1,384 feet (422 m.) above the sea level. Two soundings one 12 miles (19 km.) north of the lower end of the lake, and another four miles (6·4 km.) north of Halcyon, give 490 and 720+ feet (149 and 219+m.) respectively.

From Arrowhead to Revelstoke Columbia river trends N. 35° W. and is a navigable stream for shallow draught steamers. The river meanders with blind channels through flat bottom land from 1 to 1·5 miles (1·6 to 2·4 km.) wide. For six miles (9·6 km.) above Arrowhead low flats border both sides of the river. Above that point they lie alternately on one side of the river or the other. Below Revelstoke the river closely hugs the rocky western shore. The valley is continuously bordered on both sides by mountain ranges and is in that respect analogous to the valleys of the lakes to the south.

The shore line of these lakes is steep with numerous rocky bluffs; occasionally portions are fringed by narrow beaches and locally by more widely expanded delta deposits at the mouths of entering streams. The bordering mountain ranges are lofty and rugged and attain elevations from 6,000 feet (1,828 m.) to over 8,000 feet (2,438 m.) above sea level. Their axial lines are narrow and lie from four to six miles (6·4 to 9·6 km.) inland from the valley trench. In places the steeper slopes are scarred by landslides, the most recent one having occurred early in 1903 on the north side of the valley of the northeast arm a little to the east of Arrowhead.

The usual types of fiord topography are in evidence throughout the length of the two lakes, illustrating varied examples of cliff walls, truncated spurs, hanging and V-shaped lateral valleys, terraces, alluvial cones and fans and continuous evidence of heavy glacial scoring and undercutting.

The river connecting the two lakes is rather more than a mile (1·6 km.) in width, bordered by flat bottom lands and low terraces. This portion of the valley must represent an ancient and deep hollow filled in by glacial drift and later deposits. At present considerable sedimentation is being effected by the material carried down by the tributary streams.

GENERAL GEOLOGY [8].

The geology of the valley sides and neighbouring mountain ranges has not been worked up in any detail and at present only permits of a very generalized description. From Castlegar to a point about south of Saddle peak the valley is eroded in rocks of two batholithic intrusions, the earlier being the Nelson granodiorite of Jurassic (?) age, and the later the Rossland alkali granitic rocks tentatively referred to early Tertiary. The former extends from Castlegar to near Deer Park and then again from a point three miles (4·8 km.) south of the Needles to the bend in the Columbia river. The latter extends from Shields to a point three miles (4·8 km.) south of the Needles and occupies for the most part both shores of the lake. Of irregular lenticular form the batholith is 38 miles (61 km.) in length along its north axis with a maximum width of 17 miles (27 km.). Lying in these batholiths are a few remnants of the Rossland group with some associated limestone developed along the lower portions of Lower Arrow lake particularly in the vicinity of Deer Park.

South of Saddle peak a band of schists and gneisses presumably of the Shuswap series crosses the valley with a trend a little west of north.

Little is definitely known of the shores of Upper Arrow lake as far as Halcyon. The rocks are schists, gneisses, slates and crystalline limestones intruded by dykes, sills and stocks of late granites, etc. They may be referred to the Shuswap and Selkirk series together with highly metamorphosed phases of the Slocan series. They are much disturbed and faulted requiring detailed work to elucidate their structure.

From Halcyon to Arrowhead the Shuswap terrane is developed except at Thumb bay where the continuity is broken by an intrusion of granite some five miles (8 km.) wide which crosses the lake with a northwest trend.

From Arrowhead to Revelstoke the Shuswap series consists largely of orthogneisses with minor developments of mica schists, quartzite and crystalline limestone intruded by later dykes of pegmatite and aplite. The rocks are much disturbed and faulted as shown by discordant strikes and dips. In places the strike parallels the valley, in other cases it lies at right angles to it.

ANNOTATED GUIDE.

Nakusp—The upper terraces behind the town represent in part the delta deposits of Kuskanax and Nakusp creeks. The low delta face of the former creek has extended well into the lake. Ten miles (16 km.) up the Kuskanax are a series of hot springs, as yet but little known, though readily accessible by trail.

St. Leon—St. Leon marks the junction of two streams in modified V-shaped valleys. The upper delta terraces are about 200 feet (60 m.) above the lake. About one mile (16 km.) inland hot springs occur.

Halcyon—At Halcyon are the most noted of the hot springs which appear at intervals along the east side of Upper Arrow lake. There are two adjoining springs about 1,700 feet (518 m.) inland and 400 feet (122 m.) above the lake. The water flows from two orifices in biotite gneiss at a temperature of 124° F. (68·8° C.) with an estimated flow of 300 gallons per minute. An analysis made by J. F. King in the laboratory of the City Analyst, Edinburgh, March 3, 1898, showed the water to contain the following ingredients expressed in parts:

Chlorine	8·14
Sulphuric acid	363·43
Silica	74·29
Lime	84·57
Alkalies as soda	5·71
Magnesia	232·
Lithia	0·86
Sulphuretted hydrogen	32·

Looking west from Halcyon across the lake a range is to be seen in which are many lofty peaks with glaciers and snowfields. This range extends to near Revelstoke where

the culminating peak Mount Begbie has an elevation of 8,946 feet (2,726 m.) above the sea.

Arrowhead—On approching Arrowhead a good view is obtained of the peaks and snow fields at the head of the northeast arm, and of the scar left by the landside of 1903. On the face of the hill directly behind the town two heavy sills of granite are intruded in the Shuswap schists. The upper sill has a marked vertical jointing.

Wigwam—At Wigwam rock terraces mark the floor of the more ancient valley. The Akolkolex river entering from the east, affords a striking example of a hanging valley.

Revelstoke—The city is on the main line of the Canadian Pacific railway, situated at the junction of the Columbia and Illecillewaet rivers.

SLOCAN SILVER-LEAD DISTRICT.

ANNOTATED GUIDE.

(South Slocan to New Denver).

Miles and Kilometres.

South Slocan—Alt. 1637 ft. (499 m.) is 12 miles (19 km.) west of Nelson and is the junction point of the railway branch running north to Slocan lake and the silver-lead and zinc mines of the Slocan district. The railway closely follows the Slocan river which in places has cut down to bed rock though along most of its course it flows in a channel eroded in the heavy deposits of stratified sand, sandy clay and gravels which have filled the rather broad U-shaped valley to a considerable depth. The bed rock is mainly the granodiorite and associated types of the Nelson batholith. Between Koch and Winlaw there is an area of gneisses and schists lying in the granodiorite which are referred to the Shuswap series.

43 miles 69 km. **Slocan City**—Alt. 1,777 ft. (541 m.) lies at the foot of the lake of the same name and is the point of departure to the silver mines lying at the east in the granitic rocks. The ores are mainly dry, that is the silver values usually

Miles and Kilometres.

predominate over the lead and the gangue is essentially quartz. Slocan lake is of the same type as Kootenay and the Arrow lakes. The several features, however, of mountain peak, glacier and delta give it a beauty peculiarly its own and by many is considered the most beautiful lake from a scenic view point in southern British Columbia.

The lower half of the lake is eroded in the granitic rocks of the Nelson batholith, the main part of the upper half lies on the contact of those rocks with those of the Slocan slates. The form of the lake is bow-like with the convex side to the east. It has a length of about 25 miles (40 km.) and an average width of one mile (1·6 km.) with a low water elevation of 1,761 feet (537 m). Two soundings, one near the south end and one opposite Roseberry give respective depths of 925 and 765 feet (282 and 233 m.).

62 miles 100 km. **Silverton** is situated on the delta of Four-mile creek. It is the distributing point for several silver-lead mines, the more important being the Standard, Hewitt and Van Roi, and the L-H gold mine.

65 miles 104 km. **New Denver** is situated on the delta of Carpenter creek and is within easy distance of the majority of the most important silver-lead and zinc mines of the Slocan district, the principal centres being Silverton, Sandon, McGuigan and Whitewater.

Silver-Lead and Zinc Deiosits.

The district in which productive ore bodies have been found comprises the Ainsworth, Slocan and Slocan City Mining divisions. The district lies within the Selkirk system of the Cordillera and is characterized by strong relief showing all the more prominent features of alpine topography. The maximum vertical range between mountain peak and valley is over 6000 feet (1828 m). Most of the veins occur well up on the mountain slopes and consequently the mines are invariably developed by series of tunnels.

Although the lead deposits in the vicinity of Ainsworth on Kootenay lake were being worked in the later 80's, it was not until 1891 that the richer and more important ore deposits were staked inland from Kootenay lake and further to the west. In the early years the transportation difficulties were great, so that it was not until 1895 that important shipments were made. The total production from 1895 to the end of 1911 in round numbers amounts to 795,000 tons of ore, containing 30,875,000 ounces of silver, 2890 ounces of gold, 269,460,000 pounds of lead with a total value of nearly $29,000,000. The zinc returns from 1907 to 1911 are valued at nearly $1,000,000.

General Geology—The deposits occur in the granitic works of the Nelson batholith but particularly in the sedimentary rocks of the Slocan series (Carboniferous?). The granitic rocks range from true granite to quartz diorite. They are almost prevailingly of a light grey colour and the texture ranges from medium to coarse grain. Outside of the main area of the batholith the rocks appear in the sedimentaries as dykes, stocks and irregular masses.

The Slocan series consists of interbedded argillaceous quartzites and limestones, and slates or argillites which are more or less carbonaceous. They form an undoubtedly thick series, but the folding, faulting and lithological similarity prevent any section being made that would give even an approximation to the actual thickness. The series is extensively dyked by quartz porphyry and lamprophyres which are older than the fissure system containing the ore bodies.

Veins—The veins are nearly all of the fissure type and are much more numerous in the Slocan series. There they almost invariably cut across the strike of the formation, if they coincide in strike they cut across the dip and terminate usually by either turning suddenly and following a bedding plane or by feathering out in the broader bands of the softer slates. The veins vary in length from a few hundred feet to over 4000 feet (1219 m.) and in thickness from a few inches (cm) to over 50 feet (18 m.). In exceptional cases the vein may attain a thickness of 150 feet (45 m).

The widest portions of the veins are generally filled with crushed and broken country rock with but relatively small amounts of the gangue minerals. In certain definite areas the fissures form a widely parallel system; the dips

range from 40 to 80 degrees and as a rule are well over 50 degrees.

Ore shoots—The ore shoots are composite in character and consist of widely parallel bands, lenses and masses of galena and zinc blende alternating with siderite and to a less extent with quartz and calcite. As a rule the high grade ore favours the hanging wall side of the vein, though this is not invariably so. The shoots also favour the carbonaceous slates rather than the quartzites, porphyry stocks or dykes, but the reverse again holds in a few instances. Another favourable factor in the formation of shoots is the cross fissures which pass across the vein from either the foot or hanging wall side. These appear to have formed accessible channels for the metal bearing solutions. The shoots vary in length from 15 or 20 feet (4·5 or 6 m.) to 400 feet (122 m.) or over, and in width from a few inches (cm) to 40 feet (12 m.).

The vertical component varies from 10 feet (3 m.) or so to 500 and 600 feet (152 to 182 m.) in the larger bodies. In many cases with, however, numerous exceptions, the shoot bears a relation to the topography of the country and pitches out of the hill. With depth the ore gets poorer and passes into slightly mineralized gangue and crushed rock.

Mineral composition—The chief metallic minerals are galena and zinc blende. With freibergite as the important silver bearing ore, ruby and native silver and argentite are found in many of the deposits developed along fractures in the more massive ore. Chalcopyrite and pyrite are almost invariably present, the former in small amount, the latter in increasing quantity as the lead content diminishes. The zone of weathering is very shallow but originally contained carbonates of lead, zinc and copper and in one instance linarite, a sulphate of lead and copper.

The gangue is composed of siderite, calcite and quartz in varying proportions, the quartz content usually increasing with depth.

At present the metallic contents of the ores mined range from 7 per cent of lead and 20 ounces of silver to the ton to one carrying from 50 to 75 per cent of lead and from 80 to 175 ounces of silver to the ton. In some mines there is a little gold which ranges in value from $1.00 to $7.00 to the ton.

Origin—No definite law holds with regard to the order of the formation of the several minerals. In many instances however, siderite was formed first, followed by zinc blende which replaced a portion of the siderite. Galena succeeded the blende, and freibergite followed, filling in fractures in the galena and to a certain extent in the blende.

The ore appears in great part to be primary and to have been introduced by ascending solutions which deposited their mineral content in the wider portions of the veins at favourable horizons, where the action was aided by decrease of pressure, lower temperature and by the reducing action of the carbon in the crushed rock which forms an important percentage of the vein filling.

The ore was probably derived from some horizon of the granitic rocks of the batholith which underlies the whole area and is perhaps closely connected with the basic lamprophyric dykes. In several instances it was noted that veins followed the same fissures as the dykes, in which cases the ore lay on and along the dyke.

Many of the ore shoots so far stoped have been comparatively shallow, but more recent development work has shown ore at greater depths, in one case 1,270 feet (387 m.) below the outcrop. The development of the last two years has encouraged the belief that the ore shoots are not merely surface deposits but that they will be found to have a much greater vertical range than was formerly believed.

Annotated Guide (Continued).

Miles and Kilometres.

69 m.
111 km. **Roseberry** is situated on the delta of Wilson creek at an elevation of 1,795 feet (547 m.) above the sea. Just north of the station the railway crosses an apophysis of the granodiorite intruded in the Slocan slates. Slocan lake terminates north of Hills, but the valley trench continues through to Nakusp, the railway following closely the contact between the Slocan series and the granodiorite. About a mile (1·6 km.) north of Hills the abandoned valley of the creek draining Summit lake is exposed, the present creek flowing in a valley a little further to the west.

Miles and Kilometres.

At the summit the elevation is 2,500 feet (762 m.), and from there the railway descends to Nakusp passing across the upper terraces and delta deposits of Kuskanax and Nakusp creeks and finally arriving on the present delta by means of a long switch back.

97 m. 156 km. **Nakusp.**

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THE SIMILKAMEEN DISTRICT.

Midway to Spence's Bridge.

BY

CHARLES CAMSELL.

INTRODUCTION.

The Similkameen excursion leaves the route of Excursion C2 at Midway, and after proceeding westward along the valley of Similkameen river turns northward at Tulameen towards Nicola river, and at Spence's Bridge, where this stream enters Thompson river, it again joins the route of Excursion C2.

This route of this excursion lies almost entirely in the Interior Plateau region of British Columbia, and an excellent opportunity is afforded of viewing what is one of the main physiographic features of the province of British Columbia. The characteristic features of mature topographic outline in this region are believed to have been produced by sub-aerial erosion acting throughout Eocene times, though they have been somewhat modified by subsequent events which include regional elevation, vulcanism and glaciation. The region is underlain by sedimentary and volcanic rocks ranging in age from Carboniferous to Miocene, the older of which have been intruded by batholithic igneous rocks.

The chief points of scientific and economic interest which it is the object of this excursion to visit are: the gold bearing arsenopyrite deposits of the Nickel Plate mine,

and the roof contact of a granodiorite batholith, at Hedley; Oligocene lake basins at Princeton, and Nicola; the platinum and diamond bearing peridotite, at Tulameen.

ANNOTATED GUIDE.

MIDWAY TO HEDLEY.

Miles and Kilometres.

0 m. **Midway**—Alt. 1,908 ft. (581·5 m.). Midway
0 km. is a small town of a few hundred inhabitants, situated in the drift-filled valley of Kettle river at the mouth of Boundary creek. It lies in an area of Oligocene rocks, consisting of somewhat disturbed volcanic flows and tuffs, interbedded with sandstones and shales. Associated with them are some thin seams amd lenses of lignite.

For three miles (4·8 m.) beyond Midway the Great Northern railway runs westward along the valleys of Kettle river and Myers creek through an open, wooded, park-like country, and after passing through a tunnel enters a narrow gorge, cut in massive Oligicene lavas.

9 m. **Bergen**—Alt. 2,409 ft. (733·2 m.). Beyond
14·5 km. Bergen the valley broadens into open, grassy meadows, partly under cultivation, and in the railway cuttings are exposures of Oligocene slates and sandstones which dip eastward and form the western border of the basin through which the railway has run from Midway. These rocks resc unconformably on much disturbed and compressed Palæozoic schists, which are considered to be of Carboniferous age and correlated with the Cache Creek group. They extend for two and a half miles along the railway, to Mile post 79, where they give place to a body of Jurassic granodiorite which is intrusive into them.

14 m. **Myncaster**—Alt. 2,732 ft. (832·4 m.). Palæo-
22·5 km. zoic schists again appear at Myncaster, replacing the granodiorite. From this point the railway turns abruptly to the north and after series of sharp curves crosses from the valley of Myers creek to that of Rock creek.

Miles and Kilometres.

It follows the south slope of Rock creek valley westward through a small area of Tertiary volcanic rocks and on leaving it to ascend the valley of Baker creek, it again enters Palæozoic rocks, exposures of which can be seen in the railway cuts.

26 m.
41·8 km. **Bridesville**—Alt. 3,407 ft. (1,038 m.). Near the head of Baker creek the railway crosses the International Boundary line at a point two miles east of Molson, and from this pont westward to Chopaka on the Similkameen river, the route lies in the State of Washington.

31 m.
49·8 km. **Molson**—Alt. 3,705 ft. (1,128 m.). Molson is situated on the divide between Kettle river and Okanagan river, in a region characterized by rounded, grassy hills, on which there are few exposures of the solid rocks. From here an imperfect view can be obtained to the north and west of a part of the great Interior Palateau of British Columbia, noteworthy features of which are the evenness of its skyline, and the maturity of its topographic forms. From Molson a descent of 2,764 feet (825 m.) is made down a grassy open slope to the bottom of Okanagan valley to Oroville, which is distant 25 miles (40·2 km.).

42 m.
67·6 km. **Circle**—Alt. 2,571 ft. (783 m.). The old Palæozoic rocks, through which the railway has run from Bridesville, are overlapped at Circle by Tertiary rocks consisting of sandstones, shales, and lavas, which cover the slope of Okanagan valley virtually to Oroville.

56 m.
90 km. **Oroville**—Alt. 941 ft. (286·8 m.). Oroville, a town of about one thousand inhabitants, is situated in Okanagan valley at the south end of Osoyoos lake and at the entrance of the Similkameen river. Geologically it lies in one of the interior lake basins of Oligocene age, the rocks of which consist of conglomerates, sandstones, and shale associated with some volcanic flows. Okanagan valley, which has been cut through this basin, is one of the main north and south valleys of the Cordilleran region, and during the Glacial period was occupied by the southward

Miles and Kilometres.

moving Okanagan glacier. Evidences of its occupation by this glacier are still preserved in the shape of the valley, in numerous glacial striae, and accumulations of glacial material. The width and climate of the valley make it excellent for fruit growing which is the principal industry of the district.

The railway crosses Okanagan valley at right angles at Oroville and enters the valley of Similkameen river, which it follows as far as the town of Princeton, a distance of 80 miles (128·7 km.).

The Similkameen river belongs to the Columbia drainage system. It rises on the eastern slope of the western ranges of the Cascade mountain system, and, flowing at first in a northerly direction and afterwards westward, cuts at right angles through the axis of the Okanagan range in the neighbourhood of Keremeos. Its valley is antecedent to the formation of the Okanagan range, which is believed to have been elevated in Pliocene times. During the Glacial period it was occupied by a great valley glacier moving south-eastward to join the Okanagan glacier. The truncated spurs and characteristic U-shape, which it has near the International Boundary line, are evidences of that occupation.

For 12 miles (19·3 km.) above Oroville the Similkameen river has an easterly trend, and as this direction is approximately at right angles to the movement of glacial ice, its valley has not been greatly modified and is still narrow and in places canyon-like. A bed of hard Tertiary conglomerate makes a barrier across the river and causes a fall of 23 feet (7 m.) at which 500 electrical horse power is developed to supply neighbouring towns.

67 m. 106 km. **Nighthawk**—Alt. 1,130 ft. (344 m.). The Tertiary rocks of this part of the valley rest directly on Palæozoic schists and limestones of Carboniferous age, and wherever they are exposed some prospecting and mining development has been carried out principally on gold

The trough-shaped glaciated valley of Similkameen river.

Geological Survey, Canada.

Route map between **Midway** and **Princeton**

Miles
10 5 0 10 20
Kilometres
10 5 0 10 20 30

Miles and Kilometres.

ores. The Palæozoic rocks are intruded by granodiorite, probably Tertiary in age, the contact crossing the valley 3 miles (4·83 km.) east of Nighthawk.

77 m. 124 km. **Chopaka**—Alt. 1,150 ft. (350·5 m.). Beyond Nighthawk, the railway enters a broad glaciated valley, running almost north and south, and turning sharply to the north within a few miles crosses the International Boundary line into Canada at Chopaka. From here northward to Keremeos the river and railway follow the eastern foot of the Okanagan mountains, the extreme eastern range of the Cascade system, which rises abruptly from the valley bottom to an elevation of 8,000 feet (2,438 m.) above sea level. Crossing the Similkameen river 4 miles (6·4 km.) north of the boundary line, where the Palæozoic rocks are again in contact with the granodiorite, the railway keeps the eastern side of the stream for several miles. These Palæozoic rocks form both sides of the valley almost up to Hedley, except where they are capped by almost horizontally Tertiary volcanic rocks on the east side of the valley below Keremeos.

94 m. 151·2 km. **Keremeos**—Alt 1,330 ft. (405·4 m.). Keremeos, situated at the mouth of Keremeos creek, and formerly one of the oldest Hudsons Bay Company's fur trading posts in the district, is now the centre of a good fru t farming country. Gold-copper deposits in the mountains to the north make it important from a mining point of view.

Above Keremeos Similkameen river cuts a broad but steep-sided valley through the axis of the Okanagan range, which is here built out of Palæozoic sediments and volcanics. A series of talus slopes, remarkable for their great size and length are developed on the north side of the valley.

101 m. 162·5 km. **Ashnola**—Alt. 1,420 ft. (432·2 m.). Seven miles (11·26 km.) above Keremeos Ashnola river, a swift turbulent stream, draining the high mountainous region about the International Boundary line, enters from the south. The

Miles and Kilometres. railway is here on the south side of the river, but soon crosses back to the north, and after passing Bradshaw, reaches the town of Hedley at the mouth of Twentymile creek.

107 m. 172 km. **Bradshaw.**—

112 m. 165·7 km. **Hedley**—Alt. 1,650 ft. (502 m.).

GEOLOGY OF THE REGION ABOUT HEDLEY.

GENERAL DESCRIPTION.

Physiography. The Hedley district [**2**,] lies in the Interior Plateau region of southern British Columbia on the western flank of the Okanagan range of mountains, which is an elongation of the Cascade Mountain system. The plateau occupies the whole of the central part of British Columbia, and is characterized in its upper levels by wide flaring valleys separating broadly rounded or almost flat topped summits which merge together in an almost level sky line, having an elevation in this part of about 6,000 feet (1,827 m.) above sea level. Into the surface of the plateau the master streams have entrenched themselves to a depth of 2,000 feet (609 m.) or more, and now occupy steep sided valleys, which have been modified by valley glaciation to produce the characteristic U-shape typical of Similkameen valley.

To the long erosion period following the Laramide uplift is due the uniformity of level of the upper surfaces of the region, while the entrenchment of the streams in the deep valleys is attributed to the period following the uplift of the Interior Plateau and Cascade mountains in late Pliocene times. A topographic break, occurring about the 4,000 foot (1,219 m.) contour in the grade of the small streams and projecting spurs entering the Similkameen valley, is used as evidence in support of the idea that the degree of uplift in this region during Pliocene times was at least 2,500 feet (762 m.).

The effects of both continental and valley glaciation are apparent throughout the region. On the upper levels continental glaciation has accentuated the maturity of

relief by depositing a mantle of drift over the surface of the region while in the main valleys the effect of valley glaciation is evident in deepening and in transforming what must have been a V-shape into a well marked U-shape.

Valley glaciation has probably been, in part at least, the cause of the formation of the hanging valleys, which are so marked a feature of the Hedley district. Unequal deepening of the main and tributary valleys by streams revived by uplift may, however, also have been partly responsible for the hanging valleys.

The location of the valleys of the smaller streams along their present courses has been dependent, in many cases, upon the structure of the underlying rocks, and they are consequently subsequent streams. It is not so clear what were the causes determining the course and direction of Similkameen river. It is inferred, however, from the way in which that stream cuts across the axis of the Okanagan range, that it must have occupied its present bed prior to the Pliocene uplift, and consequently in relation to the Okanagan range, it is an antecedent stream.

Geology. The oldest rocks of the Hedley district are of Carboniferous age and consist of massive limestones, thin bedded quartzites and argillites, and a great thickness of volcanic tuffs. They have been folded by pressure exerted in an east and west direction, and in consequence dip towards the west at angles varying from 15 to 90 degrees. They are traversed by two sets of faults which strike roughly northeast and northwest.

Plutonic igneous rocks have been intruded through the sedimentary rocks in the following order:—(1) diorite and gabbro, (2) granodiorite. These igneous rocks have been accompanied by a great number of apophyses, and followed by lamprophyres, and other dyke rocks.

Over all is a thin mantle of glacial and post-glacial deposits.

The following is a table of formations:—

Quaternary—Stream deposits and glacial drift.

Tertiary?—Granodiorite.

Mesozoic?—Diorite and gabbro.

Carboniferous?—Limestone, quartzite, argillite, and volcanic materials.

The ore deposits of the district are of contact metamorphic origin and of a type unique among North American deposits. They contain gold, the only valuable con-

stituent, associated with arsenopyrite in a gangue of quartz, calcite, epidote, garnet, diopside, and other lime-silicate minerals. The ore bodies are of irregular shape and without clearly defined boundaries.

They occur in altered silicified limestone beds of Carboniferous age at the contact of intrusive sheets and dykes of a light coloured gabbro, which appear to have emanated from a central stock of the same material. They appear to be genetically connected with the gabbro, and to have been formed at the time of intrusion of that rock into the limestone. The ore bodies being worked contain gold to the value of about $11.00 to the ton, and the mines are the biggest producers of gold alone of any mines in British Columbia.

The deposits were discovered in 1894 and in 1904, actual milling of the ores began and has since continued without interruption.

PARTICULAR DESCRIPTIONS.

The chief points of geological interest at Hedley, which it is the object of the excursion to visit are the following:

(1) Roof contact of a granodiorite batholith, exposed near the stamp mill of the Hedley Gold Mining company.

(2) The Interior Plateau, to be seen from the top of Nickel Plate mountain.

(3) The Nickel Plate mine.

Roof contact of Granodiorite batholith.

An excellent section, showing the roof contact of a granodiorite batholith with tilted Carboniferous sedimentary strata, is exposed on the northern side of Similkameen valley east of the town of Hedley, and can be seen in a large way from the railway station.

The contact illustrates a case of differentiation in a slowly cooling, igneous magma by the rising of the lighter constituents, quartz and feldspar, to the upper surface of the batholith, and the filling of pockets and fractures in the sedimentary roof by these lighter constituents, where they form aplite and quartz porphyry dykes and even quartz veins.

It also illustrates in certain features the theory of batholithic intrusion by stoping; there is little structural disturbance in the intruded rocks; the contact line in

Geological Survey, Canada

Natural Section of **Nickel Plate Mountain** showing the roof contact of the granodiorite batholith

detail is angular; and the batholith contains many inclusions of the intruded rocks, some of them recrystallized.

The base of the mountain, as seen from the railway station, is composed of massive granodiorite for the first 500 feet (152 m.) above the valley flat. Above are steeper cliffs of interbanded sediments and intrusive porphyrite sheets dipping to the west at about 30 degrees. The contact is approximately horizontal, and the intruded rocks are truncated by the batholith with little or no structural disturbance.

The granodiorite is a light-coloured, medium-grained rock consisting of feldspar, quartz, biotite and hornblende. It contains many dark inclusions and segregations varying from 2 to 10 inches (5 to 25 centimetres) in diameter. Some of these are angular and some are oval. The angular ones are, without doubt, inclusions of either limestone or quartzite. The rounded ones are recrystallizations and may represent fragments stoped from the roof and recrystallized by the heat of the magma.

The accompanying section illustrates the nature of the contact, and it is noticeable that the acid contact zone is thick in pockets in the roof of the batholith, while it is comparatively thin or almost absent where a corner projecting down into the batholith forms the roof.

On approaching the contact from below at one of these pockets and at a distance of about 40 feet (12·2 m.) below the roof, the granodiorite has its normal characteristics. At 25 feet (7·6 m.) from the contact there is a noticeable change due to the partial elimination of the basic minerals, and at 15 feet (4·5 m.) away these minerals are almost entirely absent, and the rock becomes a fine-grained pink variety made up largely of quartz, orthoclase, a little plagioclase, and small flakes of biotite. A tendency to porphyritic structure is also developed. Within three feet (·9 m.) of the contact the change is most marked, and the rock is noticeably more silicious. The porphyritic structure is also well developed, the rock becoming a quartz porphyry traversed by many small veins of guartz. The thin section shows this rock to consist of phenocrysts of orthoclase and quartz, sometimes exhibiting a micrographic intergrowth, in a fine-grained ground mass of the same minerals also intergrown together in the same structure. At the actual contact is about two inches (5 cm.) of perfectly white, fine-grained, soft rock, now so decomposed as to

be indeterminable. The contact is a sharp, clean-cut line showing no blending of the two rocks, and above is a coarse-grained crystalline limestone.

Apophyses from the granodiorite into the roof are of the same character as the contact zone. They are very silicious quartz porphyries, which, a few hundred feet from the contact, become quartz veins.

Interior Plateau.

From the upper terminal of the Hedley Gold Mining Company's gravity tramway, at an elevation of 5,400 feet (1,646 m.) above sea level, an excellent view of the Interior Plateau is obtained looking west. The plateau seen from this point is merely a bay at the southern end, lying between the Okanagan range on the east and the Hozameen range on the west, with the Princeton depression in its central part. The main extent of the plateau is towards the north, in which direction it stretches, with a width of about 100 miles (160 km.) far into the northern interior of British Columbia.

Considerable doubt still exists relative to the history and development of the characteristic features of the Interior Plateau region. A maturity of relief and an evenness of sky line, probably not amounting to actual peneplanation, are believed to have been produced by subaerial erosion acting throughout Eocene times. To some extent, at least, these features have been preserved in the present topography of the region; and although much of the region has undergone considerable disturbance by mountain building forces and vulcanism, in the succeeding periods, local irregularities of the surface produced at such periods were again reduced by erosion in the quiescent periods following them, especially in early Pliocene. Since, therefore, the Interior Plateau region has been subject to erosive action throughout the whole of Tertiary times, its present physiographic characteristics should be considered as the cumulative result of that long period of time, rather than of any single period of the Tertiary. There is no doubt that at a time immediately preceding the Pliocene uplift the vertical relief in the region must have been fairly low and the maturity of form much more pronounced than at the present time. The Pliocene uplift is estimated to have elevated this region about 2,500 feet (762 m.) higher above sea-level than its pre-Pliocene level, and the deep trough-

General view of Interior Plateau region.

like valleys,—of which the Similkameen valley is a typical example—are the result of stream erosion following that uplift. These valleys have, however, since been modified by glaciation to their present U-shape. Glaciation has also, to some extent, been responsible for smoothing out the irregularities of the surface and reducing the summit levels of the region.

Nickel Plate Mine.

The Nickel Plate mine is situated on the eastern slope of Nickel Plate mountain at an elevation of about 5,700 feet (1,737 m.) above sea level. The ore deposits in it are of contact metamorphic origin and occur at the contact of dykes and sheets of gabbro in limestones which have been altered by the gabbro. They are irregular in outline and have usually a well-defined boundary only on the side of the gabbro.

The gangue of the ore bodies contains minerals formed by the alteration of limestone, including garnet, epidote, diopside, amphibole, quartz, calcite, and axinite.

The principal ore mineral is arsenopyrite, with which occur chalcopyrite, pyrrhotite, zinc blende, pyrite, native gold, and sometimes tetradymite. These minerals are distributed through the gangue in crystallized individuals, or fill minute fractures in it. The valuable content of the ore is gold alone, which in that now being mined, averages about $11.00 to the ton.

These deposits afford an excellent illustration of contact metamorphism induced by the intrusion of igneous bodies into calcareous rocks, and show the resulting alteration of the original carbonates to silicates. They illustrate also the formation of ore bodies by the transfer of ore material from the igneous rock to the sedimentary, under such conditions of temperature and pressure, that the constituents introduced, and those originally present and recrystallized, are intergrown together as a result of contemporaneous crystallization.

In the association of gold with arsenopyrite in deposits of this origin the Nickel Plate ore deposits are unique and have no known counterpart on the continent. In the classification of ore deposits, they are therefore placed in a division by themselves, and are called the "Arsenopyrite type" of contact metamorphic deposits.

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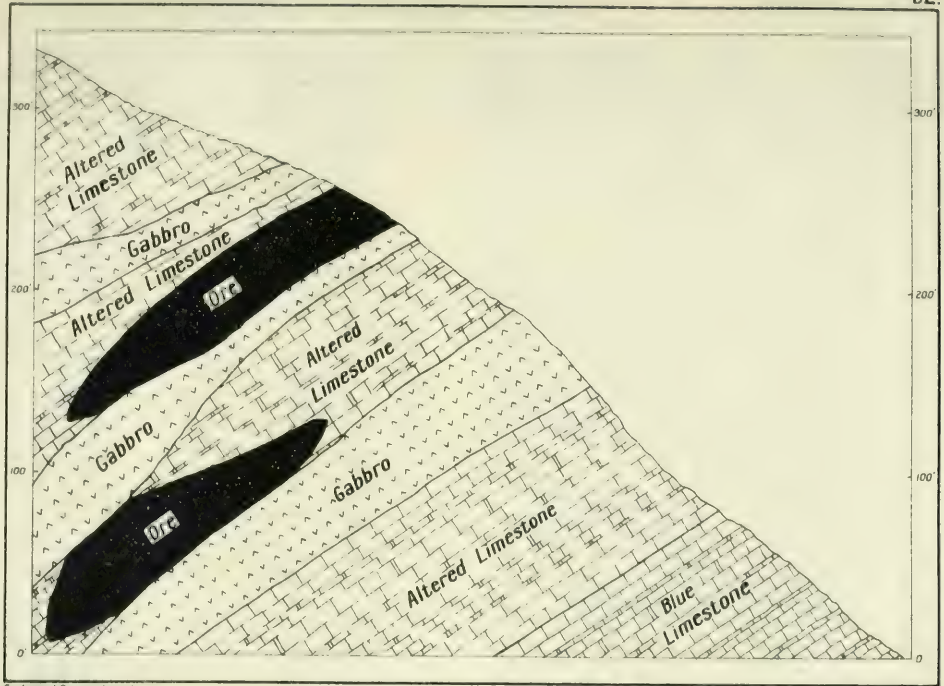

Geological Survey, Canada

Section through the **Nickel Plate Mine**.
showing the relation of the ore bodies to the gabbro intrusives

INDUSTRIAL NOTES.

At the present time the chief industry of Hedley is mining, and the activity of the district depends on the operation of the mines and the reduction works of the Hedley Gold Mining Company, and to prospecting and development work on mining claims in the surrounding region.

The Hedley Gold Mining Company employs about 60 men in the Nickel Plate and Sunnyside mines on the top of Nickel Plate mountain, and operates a system of electric and gravity tramways which carry the ore from the mines to the mill. The electric tramway is about a mile in length, while the gravity tramway is 10,000 feet (3,048 m.) in length, and drops nearly 4,000 feet (1,219 m).

The mill is situated at the town of Hedley and treats an average of 160 tons of ore per day. It is equipped with 40 stamps, two tube mills, and cyanide tanks, and is operated either by water power or steam. The ore being treated has an average value of about $11.00 to the ton from which an extraction of 95 per cent of gold is made. Up to 1913 a total of about $3,250,000 in gold has been recovered from Nickel Plate ores mined.

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2. Camsell, Charles. Memoir No. 2. Geol. Survey of Canada, 1910.

ANNOTATED GUIDE.

Miles and Kilometres.

124 m. 200 km. **Bromley**—For four miles (6·4 km.) beyond Hedley the rocks along the railway

133 m. 214 km. **Allison**— are Palæozoic slates, limestones, and schists, good exposures of which can be seen in the bluffs which face the river at several points. Shortly after crossing Sterling creek, the railway enters a batholithic body of

Miles and Kilometres.

granodiorite, which extends up the valley for about 10 miles (16 km.) to Five Mile creek. In the granodiorite the valley is narrower and more steep-sided, and the solid rocks are exposed in many of the cliffs. After passing Five Mile creek the granodiorite is again replaced by Palæozoic slates and limestones, the contact zone of which is marked by a number of reddish dykes of granite porphyry cutting the sedimentary rocks. From this point onward to Princeton the hills bordering the valley become lower and more open, and soon after passing Allison the railway crosses the Similkameen river and enters the town of Princeton.

136 m. 219 km. **Princeton**—Altitude 2,120 ft. (646·15 m.).

GEOLOGY OF THE REGION AROUND PRINCETON.

GENERAL DESCRIPTION.

Princeton is situated at the junction of the Similkameen and Tulameen rivers, in a shallow depression in the Interior Plateau region, which was formerly an Oligocene lake basin. The region is characterized by comparatively moderate relief, gently rounded hills and broad, open valleys. It is sparsely forested, and in portions quite open and grassy, so that it affords good grazing for horses and cattle.

The principal rocks of the region are flat lying sediments of Oligocene age, resting on a basement of tilted Palæozoic rocks. They include sandstones, clays, shales, conglomerate, and coal seams, and contain a variety of fossil plants, insects, and fish remains. These rocks are overlaid by volcanic flows of andesite, basalt and fragmental materials.

The Palæozoic rocks, to the south of the town of Princeton, at Copper Mountain, contain low grade copper deposits of considerable magnitude, which are now being vigorously prospected. They carry chalcopyrite as the principal copper mineral, and are either in the form of contact metamorphic deposits situated in altered sedimentary rocks at the contact of irruptive igneous bodies, or

are in fissures in both the igneous and sedimentary rocks.

The Oligocene rocks cover an area of about 40 square miles (103 sq. km.) and contain a number of seams of coal, ranging in thickness from a few feet up to 60 feet (18·29 m.). Some of the seams are being mined. The Oligocene also includes important beds of clay which are utilized in the manufacture of cement.

PARTICULAR DESCRIPTION.

The chief features of geological interest to be seen in the vicinity of Princeton are the rocks of the Tertiary lake basin, with the coal seams which are associated with them.

In a low cliff within a few yards of the railway station a good exposure of Oligocene sandstone is seen. The sandstone is a light coloured, coarse grained, feldspathic rock dipping at a low angle towards the southwest. It shows false bedding, and has been eroded by wind or water action to form deep caves, the roof of the caves being a hard compact bed of sandstone.

On the east side of Similkameen river, at the end of the traffic bridge, the outcrop of a coal seam is seen. The total thickness of the seam is 25 feet (7·6 m.), but it contains several small bands of clay. The associated rocks are shale and sandstone. The coal dips S. 30° W. at an angle of 12 degrees and is traversed by a few normal faults which strike S. 45° W. The throw is usually only a few feet, the downthrow being on the northwest side. The mineable parts of the seam are a bench 7 feet (2·13m.) to 10 feet. (3·04 m.) thick in the upper half, and another bench 7 feet (2·13 m.) thick in the lower half. Only the upper bench is at present being worked.

The coal is sub-bituminous, excellent for domestic use and for the manufacture of gas. A sample of the seam being mined gives the following proximate analysis:—

Moisture	16·17	per cent.
Volatile combustible matter	37·58	"
Ash	4·58	"
Fixed carbon	41·67	"
	100·00	

Industrial Notes.

Coal mining is the principal industry carried on in the neighbourhood of Princeton. The coal-bearing rocks cover an area of about 40 square miles (103 sq. km.) and virtually the whole of this area is taken up in coal claims. Prospecting and development work are being carried on at a number of points in the basin, but shipment of coal is being made only from the collieries of the Princeton Coal and Land Company, situated on the east side of Similkameen river, near Princeton. The coal is mined by an entry driven on the dip of the seam. The method employed is pillar and room, with the use of coal cutting machines.

Two and a half miles (4·02 km.) southeast of Princeton, cement works have been erected, which are capable of manufacturing 2,000 barrels of cement daily. The raw materials for the cement are all obtained from a thick bed of Oligocene age, and the lime from a bed of pure crystalline limestone in the Palæozoic rocks underlying the Oligocene.

On Copper Mountain, 12 miles (19·3 km.) south of Princeton large bodies of low grade copper-gold ore are being actively prospected by the British Columbia Copper Company, and it is expected that actual mining will soon be under way.

References.

1. Camsell, Charles.....Preliminary Report on Part of the Similkameen District, G.S.C., No. 986, 1906.

ANNOTATED GUIDE (Continued).

Miles and Kilometres.

136 m.
219 km.

Princeton—Alt. 2,120 (646·15 m.). On leaving Princeton the railway follows the valley of the Similkameen river for a short distance, and then enters a tunnel which cuts through a narrow neck separating the Similkameen from Tulameen valley. From this point westward to Tulameen the line lies in Tulameen valley passing from one side of the river to the other as is found necessary.

Miles and Kilometres.

The famous Vermilion cliffs are situated on the north bank of Tulameen river about 2 miles (3·2 km.) beyond Princeton. The colour of the cliffs is due to the combustion of a coal seam, ignited, probably, by the lava which overlies it immediately to the west. The river takes its name from the cliffs, "Tulameen" being a local Indian name meaning red earth. The rocks of Vermilion cliffs contain many fossil plants.

The sedimentary Oligocene rocks are overlaid a short distance west of Vermilion cliffs by volcanic flows, and for the next three miles (4·8 km.), exposures of the two formations can be seen in the cliffs bordering the river and in the railway cuttings. Turning a sharp bend in the valley, the Tertiary rocks are replaced by Triassic rocks, consisting largely of volcanic materials with only a few sedimentary beds, and these persist almost all the way to Tulameen. These rocks are unfossiliferous, but from lithological characteristics are correlated with Dawson's Nicola series.

Placer mining for gold and platinum was at one time carried on in Tulameen valley from Princeton up to Champion creek, a distance of 28 miles (45 km.). Some of the placers were worked as early as 1860, but it was not until the discovery of coarse gold in Granite creek in 1885 that much interest was taken in them. Granite creek, which enters Tulameen river one mile below Coalmont, was the most productive stream, and the whole district at one time was the biggest producer of platinum on the continent. Some payable ground still remains on the main river and on a few of its southern tributaries, but the more easily worked deposits have long been exhausted.

148 m.
238 km.

Coalmont—Alt. 2,450 ft. (746·7 m.). Coalmont is a new town that has sprung up within the last two years as the result of the development of a coal basin on the southern side of the river at that point. The basin is of Oligocene age covering about 5 square miles, and contains a considerable quantity of coal much of

Miles and Kilometres.

which is bituminous in character. The outcrop of the coal seams lies at an elevation of about 1,300 feet (396·2 m.) above Tulameen river. The coal-bearing rocks dip into the mountain side and rest on a floor of tilted Triassic rocks. They are unconformably covered in part by a flow of olivine basalt. A tunnel has been driven 1,800 feet (548·6 m.) through Triassic rocks, and cuts the coal-bearing rocks at a depth of 700 feet (213·3 m.) below the outcrop.

152 m.
244·6 km. **Tulameen**—Alt. 2,550 ft. (777·2 m.). Four and a half miles (7·24 km.) west of Coalmont is the town of Tulameen situated at the junction of Otter and Tulameen valleys. From this point a subordinate excursion is made up Tulameen valley for the purpose of seeing some of the platinum-bearing placers, and the original locality from which diamonds were first found in place in Canada.

GEOLOGY OF THE REGION AROUND TULAMEEN.

GENERAL DESCRIPTION.

The Tulameen district is situated on the western border of the Interior Plateau of British Columbia, and a few miles east of the Hope Mountain range, which is a part of the Cascade system. The district has, in the main, the general characteristics of plateau topography with a slightly greater elevation and vertical relief owing to its proximity to the Cascade mountains.

The oldest rocks of the district consist of highly inclined green schists, andesites, limestones and argillites. These rocks are called the Tulameen series and are correlated with Dawson's Nicola series which is Triassic in age. The Tulameen series is intruded by batholithic bodies of granite and granodiorite, as well as by a stock-like mass made up of peridotite, pyroxenite, and gabbro, which are transitional into each other. These rocks are all of Jurassic age. Overlying them unconformably are slightly inclined Oligocene volcanic and sedimentary rocks,

General view of Interior Plateau region at Tulameen.

which are themselves intruded by a body of Tertiary granite. The youngest rock in the district is a flat-lying flow of olivine basalt, covering a limited area to the south east of Tulameen.

The history of the region as recorded in the rocks may be broadly summarized as follows:

(1) Deposition of Triassic sediments and volcanics.

(2) Mountain building and folding of the Triassic rocks.

(3) Batholithic intrusion of granite, peridotite and pyroxenite, and granodiorite in Jurassic period.

(4) Laramide revolution.

(5) Eocene erosion period.

(6) Extrusion of lavas, followed by deposition of coal-bearing sediments in the Oligocene period.

(7 Batholithic intrusion of granite in Miocene period.

(8) Erosion period.

(9) Extrusion of olivine basalt.

(10) Uplift of Cascade mountains and Interior Plateau in Pliocene times, followed by deepening of valleys.

(11 Glacial period.

(12) Post-Glacial uplift, and deepening of upper portion of Tulameen valley.

A variety of mineral deposits are found in the rocks of the district. The Triassic rocks contain veins and replacement deposits of gold and copper. Segregations of magnetite and chromite occur in pyroxenite and peridotite. The peridotite also contains both platinum and diamonds, usually associated with the chromite segregations. Coals are found in the sedimentary rocks of Oligocene age, and the placers of the district have yielded gold and platinum in considerable amount.

PLATINUM PLACERS.

The principal streams in the district on which platinum bearing gravels have been found are: Tulameen river below Champion creek; Slate creek; Granite creek; Newton creek. The gravels are post-glacial in origin, and are found in the stream beds and on the sides of the valleys at elevations not greater than 250 feet (76·2 m.) above the streams. Except in Tulameen river below Slate creek they are not of very great extent. All the payable

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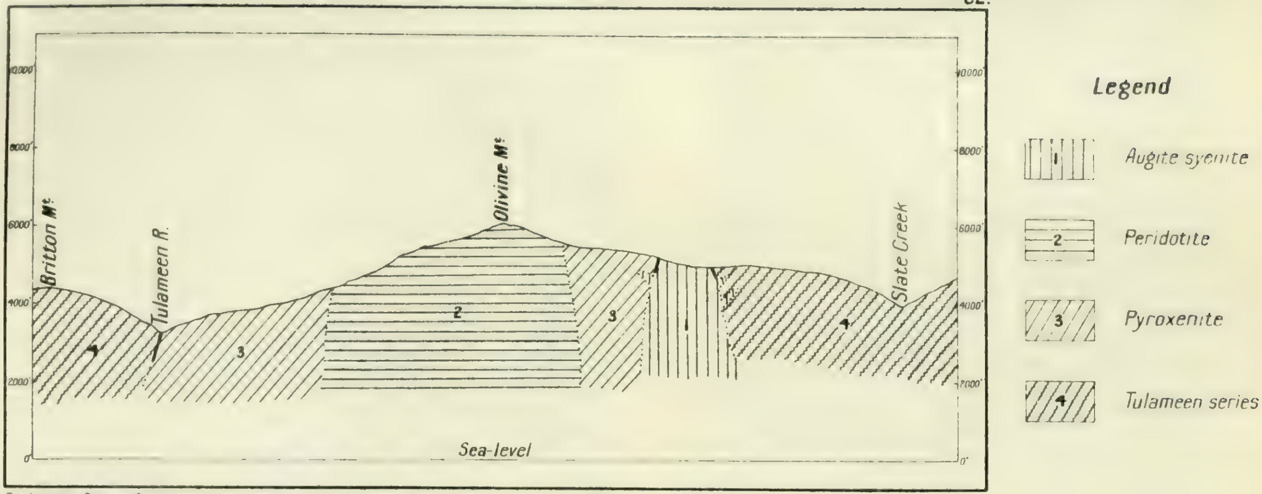

Geological Survey, Canada.

Section through Olivine Mountain

Feet

2000 0 4000 8000

Metres

1000 0 1000 2000

gravels contain both gold and platinum, the proportion varying in different streams and in different parts of the same stream. This proportion of gold to platinum varies in the streams mentioned from 4 to 1 to 1 to 1. The source of the platinum has definitely been traced to the elongated peridotite stock which crosses Tulameen river at Eagle creek and extends south-easterly from there to the head of Newton creek.

The mining of the platinum placers, which began in 1885, has up to now usually been carried on only by individual miners with the ordinary methods that such men use. Attempts have, however, been made at Eagle creek, Slate creek, and Granite creek to mine by hydraulic methods, but none of these have been very successful. Old working may be seen at several points on Tulameen river between Slate creek and Eagle creek.

The total amount of platinum obtained from the gravels has been variously estimated at 12,000 to 20,000 ounces. The present output, however, is only a few ounces annually.

DIAMONDS.

The diamond bearing rocks are most conveniently seen on the Tulameen river at the mouth of Eagle creek, 8 miles (12·8 km.) west of Tulameen village. The river at this point cuts a valley nearly 3,000 feet (914·4 m.) deep, through the middle of a large stock composed of peridotite, pyroxenite and gabbro, which is intrusive in Triassic sediments and volcanics. A vertical section through the stock, given in the accompanying diagram, illustrates the relations of the various rocks to each other. The centre of the stock is composed of peridotite, and this is surrounded on all sides by a border of pyroxenite into which the peridotite passes by a gradual change in composition, the olivine of the one rock being replaced by the pyroxene of the other. Outside the pyroxenite is a thin border of gabbro, which in places passes into an augite syenite. The syenite however also occurs in intrusive relation to the pyroxenite. It seems clear that the three rocks were originally present in one common magma, which, in the course of injection into the overlying rocks and while gradually cooling, differentiated into three distinct types, the most basic in the central part and the most acid on the outside.

Chromite occurs in the peridotite in short irregular veins and in bunches, which are clearly segregations developed in the magma during cooling. Analyses made by Mr. R. A. A. Johnston of the Geological Survey of some of these chromite segregations, taken from the north slope of Olivine mountain, yielded both platinum and diamonds in variable amount. In making the original analysis the chromite was separated into two parts, a magnetic and a non-magnetic part. The non-magnetic part yielded three per cent of diamond, and the magnetic part six per cent.

The diamond product obtained disintegrated to a powder shortly after being released from the rock, and the disintegrated particles were found on examination under the microscope to be individual crystals. Studied in thin sections, the diamonds were found to occupy small veinlets traversing the chromite.

Since the discovery of diamonds in the solid rocks the gravels of Tulameen river have been carefully examined. Gravel taken from the river in the neighbourhood of Eagle creek was panned, and a large number of small diamonds obtained along with the black sand. Small rubies were also found to be present.

Some prospecting for diamonds of commercial size is being carried on in the valley of Tulameen river, but up to the present the results have not been satisfactory. Some diamonds have been obtained, but the largest is not bigger than a pin's head.

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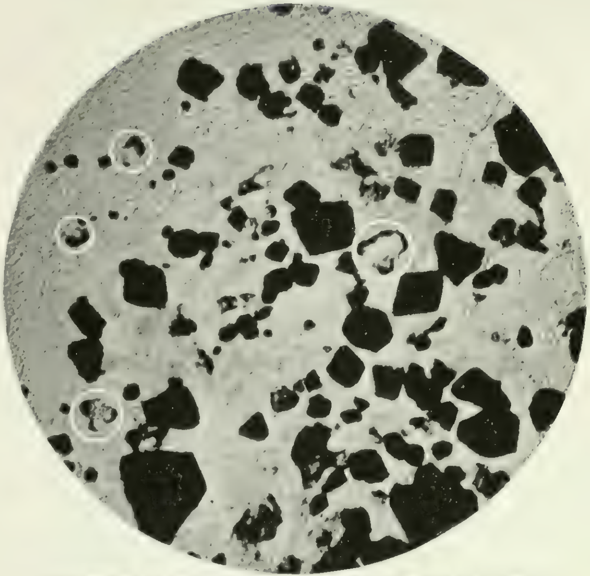
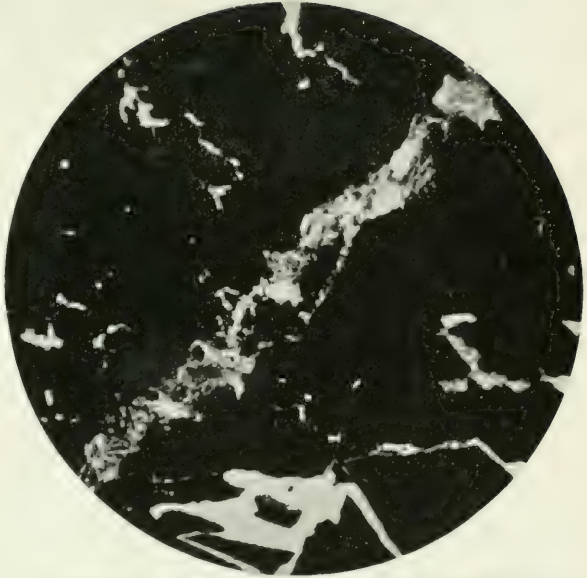
3. ....Platinum Mining in the Tulameen District, Can. Min. Inst. Vol. 13, 1910.
4. ....A new Diamond locality in the Tulameen District. Econ. Geol. Vol. 6, No. 6, 1911.



Thin section of peridotite, showing the occurrence of diamonds (within white circles) associated with chromite.



Thin section of chromite segregation in peridotite, showing the occurrence of diamonds in veinlets.

ANNOTATED GUIDE—(Contd.)

Miles and Kilometres.

0. m. 0. km. **Tulameen.**—Alt. 2,550 ft. (777·2 m.).

Otter Valley—Between Tulameen on the Great Northern railway and Merritt on the Canadian Pacific, a distance of 53 miles (85·3 km.), there is at present no railway connection and this portion of the route has to be made by carriage.

On leaving Tulameen the road runs northward up Otter valley, skirting the western shore of Otter lake for a distance of three miles (4·8 km.) in the course of which numerous exposures of a Tertiary granite are seen. Otter valley for 18 miles (28·9 km.) or as far as the forks, is a fairly broad, flat-bottomed valley, showing evidence in its shape of having been occupied by a valley glacier moving southward. It is typical of a number of deep trench-like valleys that have been developed in the Interior Plateau region. The rocks, besides the granite already mentioned, consist of Triassic schists, greenstones, and limestones extending as far as Thynne creek, beyond which younger Tertiary lava flows overlie them.

18 m. 28·9 km. **Canyon House**—At the forks of the valley, where the Canyon House is situated the valley appears to end abruptly, but the road turns sharply to the east following a narrow gorge for a few miles. In this gorge narrow beds of Tertiary sediments, which may be correlated with Dawson's Tranquille beds, rest on top of lavas and tuffs, and are covered conformably by a thick flow of columnar basalt.

Leaving Otter creek the road mounts the western slope of the valley to an elevation of 3,400 feet (1,036·3 m.) where it is virtually at the general level of the Interior Plateau. The main characteristics of the plateau are here well seen, and for the next 25 miles (40·2 km.) the road continues across the upper levels of the plateau running through an open, rolling, park-like country, which in springtime is one of the

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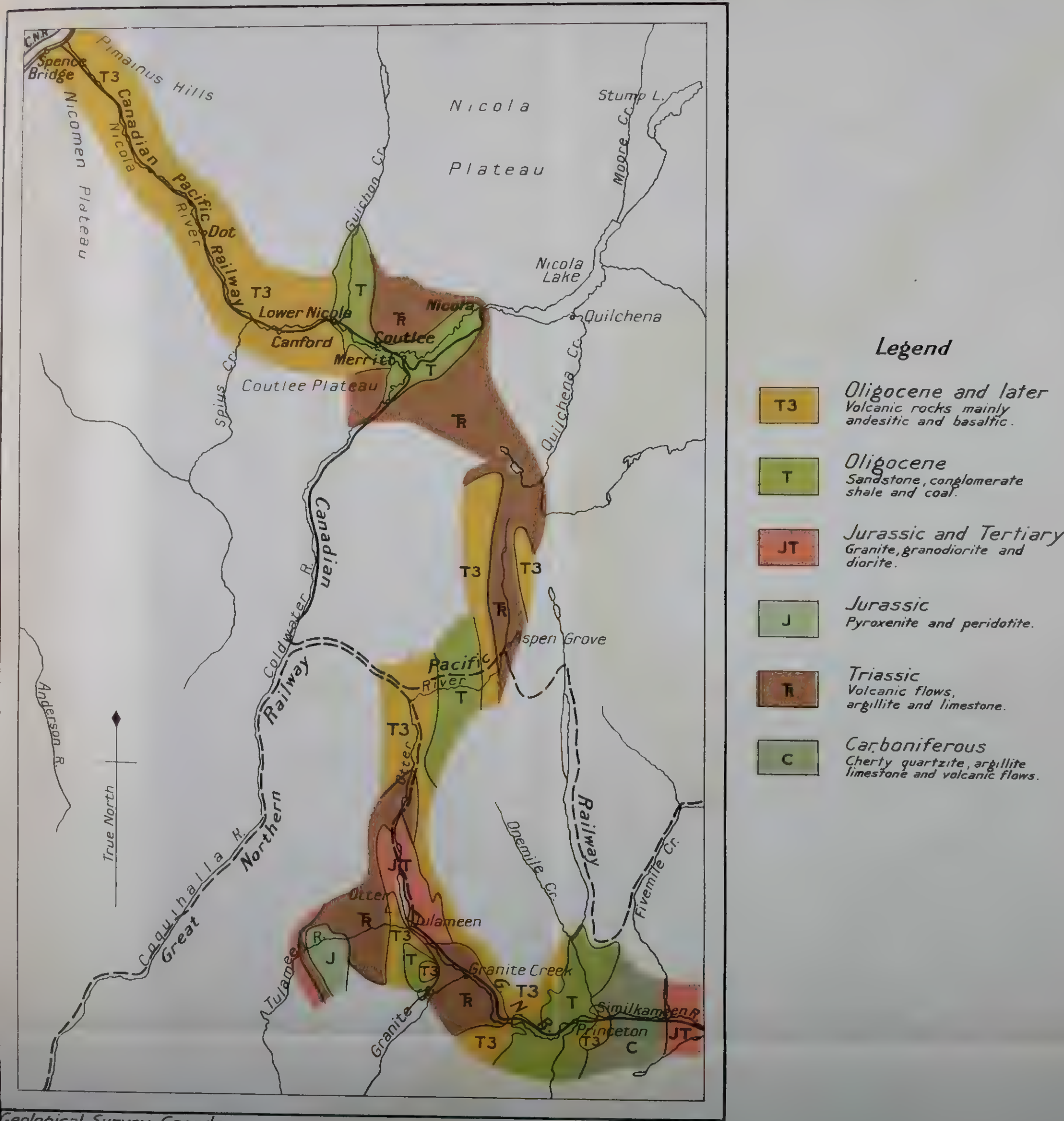

Geological Survey, Canada.

Route map between **Princeton** and **Spence Bridge**

Miles: 10 5 0 10 20

Kilometres: 10 0 10 20 30

Miles and Kilometres.

most beautiful parts of British Columbia. The country is open and grassy, or sparsely forested with large pines and dotted here and there with lakes and ponds: it is one of the best cattle raising districts in the Province.

27 m. 43·4 km. **Aspen Grove**—Alt. 3,200 ft. (975·3 m.). Near Aspen Grove, a ranch and post office, 25 miles (40·2 km.) from Merritt, the road again descends to Otter creek, which now occupies a broad, shallow trough, incised through Tertiary lavas into Triassic rocks which underlie them. On the east side of the valley are some native copper deposits, which occur as narrow fissure fillings in the Tertiary lavas. Some mining has been done on these deposits, and a slab of native copper weighing 600 pounds is stated to have been obtained from one of the mineral claims.

Nicola Valley—The highest point of the road, 3,500 feet (1,066·8 m.), above sea level is reached at an old lime kiln about nine miles (14·5 km.) from Merritt, three miles (4·8 km.) beyond which the road suddenly emerges from the forested country on to the open slope of Nicola valley. Here a most delightful view is obtained, and one is well rewarded by a stop of a few minutes to enjoy it. The bottom of the valley lies 1,500 feet (457·2 m.) below and several miles of its length can be seen from this point. Around and behind the shoulder of the hill to the north-east lies the town of Nicola, situated at the west end of Nicola lake, and directly west where the valley of Coldwater river joins that of Nicola river, can be seen the coal mines of Middlesboro and the town of Merritt, distant seven miles (11·2 km.).

52 m. 83·7 km. **Merritt**—Alt. 1,900 feet. (579·1 m.).

GEOLOGY OF THE REGION ABOUT MERRITT.

GENERAL DESCRIPTION.

The town of Merritt is situated in Nicola valley at the junction of Coldwater river with the Nicola. The district lies in the Interior Plateau region into which Nicola river has cut one of those deep, wide valleys, characteristic of the region. The bottom of the valley is about 1,900 feet (579 m.) above sea level, while the surrounding country stands 1,500 feet (457 m.) higher. The country is open or only sparsely timbered, and the slopes, though often steep, are generally covered by a thick mantle of drift.

The oldest rocks of the district are of Triassic age, and belong to the Nicola series. They consist of folded and metamorphosed volcanic flows, and some limestone and argillite. Unconformably above them are the coal-bearing Oligocene rocks which consist of sandstone, conglomerate, shale, and coal. These again are overlaid in places by more recent basaltic flows.

PARTICULAR DESCRIPTION.

The importance of the district about Merritt depends primarily on the presence of Oligocene rocks containing bituminous coals.

Like other Oligocene areas in British Columbia the rocks about Merritt are believed to have been deposited in a lake basin and since elevated to their present position. The basin covers a superficial area of about 40 square miles (103 sq. km.) all of which, however, does not appear to be underlaid by coal. The rocks consist of sandstones, shales, and conglomerates, which dip at angles varying from 10 to 40 degrees. In places the strata have been folded into anticlines, and in others faulted and considerably displaced. They contain a variety of fossil plants from which their age has been determined.

The best natural section of these rocks is that exposed in Coal gully west of the town of Middlesboro. This was measured by G. M. Dawson of the Geological Survey of Canada, and in his report of 1877-78 [**1**] he gives the following section in descending order:—

	Ft.	in.	
Soft yellowish sandstone in thin beds..........	32	0	(9·7 m.).
Coal, laminated, rather soft,..................	15	4	(4·6 m.).
Sandstone, rather soft, with some shale........	89	0	(27·1 m.).
Coal......................................	5	4	(1·6 m.).
Sandstone, with shale at the base............	141	0	(32 m.).
Coal, about...............................	3	0	(·9 m.).
Sandstone, in thin beds.....................	136	0	(33·2 m.).
Coal, about...............................	2	5	(·76 m.).

It is not definitely known how many workable seams of coal are contained within this basin, but there are four outcropping and being worked in the neighbourhood of Coal gully, and two or three others in adjacent ground to the east, each of which however may be correlated with one or another of the four known seams. In the mines of the Nicola Valley Coal & Coke Company these four seams have thicknesses of 6, (1·8 m.), 10 (3·04 m.), 5 (1·5 m.) and 12 feet (3·6 m.) respectively.

An analysis of a sample of coal taken by R. W Ells [2] of the Geological Survey and analysed in the laboratory of the Survey is given below, and probably represents the general character of the coals of this field:

Water.........................	3·04	per cent.
Volatile combustible matter......	37·18	"
Fixed carbon..................	52·05	"
Ash (reddish white)............	7·73	"
	100·00	"

Coke, per cent, 59·78. Firm, compact and coherent.

An estimate made by D. B. Dowling of the Geological Survey placed the total quantity of coal in this field at about 200 million tons.

INDUSTRIAL NOTES.

Four companies are actively engaged in mining operations in this field, namely, the Nicola Coal & Coke Company, the Inland Coal & Coke Company, the Diamond Vale Coal & Iron Mines, and the Pacific Coast Collieries. The Inland Coal & Coke Company is producing about 100 tons of coal per day, while the Nicola Valley Coal & Coke Company produces annually about 200,000 tons. Room and pillar is the method of mining employed, and no coal cutting machines are used. The mines give employment to about 400 men.

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ANNOTATED GUIDE—(Continued).

Miles and Kilometres.

0 m.
0 km. **Merritt**—Alt. 1,900 ft. (579 ·1 m.). Leaving Merritt on a branch of the Canadian Pacific railway which connects with the main line at Spence's Bridge, the course followed is westward down he broad, flat-bottomed valley of Nicola river.

2 m.
3·2 km. **Coutlee**—The railway crosses Nicola river about a mile beyond Merritt and
Coyle— passes through the small villages of Coutlee and Coyle, both of which are situated on the Oligocene coal-bearing rocks of the Coldwater series. Coyle is situated at the mouth of Guichon creek, up whose valley to the northward the same rocks extend for several miles.

12 m.
19·3 km. **Canford**—From this point downward to the Thompson river the prevailing rocks are lava flows of Tertiary age, with which, however, are associated narrow beds of coarse conglomerate and sandstone belonging to Dawson's Tranquille beds.

20 m.
32·2 km. **Dot**— Below Dot the valley narrows and
Clapperton— its grade steepens. Cliffs of white glacial silt and gravel, weathering into fantastic shapes, are frequently seen down as far as Spence's Bridge, where the Nicola river joins the Thompson.

41 m.
66 km. **Spence's Bridge**—Alt. 760 ft. (231·6 m.). From Spence's Bridge to Victoria Excursion C 2, follows the route of C 1. (See Part II., Guide Book No. 8.)

REVELSTOKE TO VICTORIA.

From Revelstoke to Vancouver the route coincides with that of Excursion C1 and a description of this section is given in Guide book No. 8, Part II. The subordinate excursion to the Nanaimo coal field, which diverges at Vancouver and rejoins the main excursion at Victoria is also described in Guide book No. 8, Part III.

VICTORIA, BRITISH COLUMBIA TO CALGARY, ALBERTA.

The east bound portion of C2 Excursion follows as far as Calgary the same route as that taken in the westward journey of C 1 the guide to which is given in Part II of Guide Book No. 8.

CALGARY, ALBERTA, TO WINNIPEG, MANITOBA VIA GRAND TRUNK PACIFIC RAILWAY.

BY

D. B. DOWLING.

CALGARY TO TOFIELD.

ANNOTATED GUIDE.

Miles and Kilometres.

Calgary—Altitude 3,425 ft. (1,044m). From Calgary to the crossing of Red Deer river, the country is underlain by sandstones of the Paskapoo series of early Tertiary age. At the crossing of the Red Deer, the outcrops show the basal beds of the Paskapoo and the coal seams (measures) that mark the top of the Edmonton (Cretaceous). This horizon is marked by a very persistent coal seam which is mined at intervals east of the railway along the Rosebud, Kneehill, Threehill and Ghostpine creeks. From Red Deer river nearly to Battle river,

Miles and Kilometres.

the same horizon is followed but the area is drift covered and outcrops are rare.

The valley of Battle river is eroded in the shales and sandstones of the Edmonton series. As Camrose is approached coal seams are again in evidence, several of which underlie the town.

The country between Camrose and Tofield is rolling and partly wooded. The coal seams in this area are being mined in a small way, where the overburden of drift is thin.

Tofield.—Altitude 2289 ft. (697m).

TOFIELD, ALBERTA, TO TETE JAUNE, BRITISH COLUMBIA.

ANNOTATED GUIDE.

Miles and Kilometres from Winnipeg.

The area traversed by the railway between Tofield and Parkgate is underlain by the rocks of the Edmonton formation, with possibly a band of overlying Paskapoo which extends northwards and may cross the railway between Junkins and Leaman. Westwards, between Hinton and Parkgate, Cretaceous rocks lower than the Edmonton may be found to outcrop. Throughout this whole belt the strata in the eastern half are but slightly inclined to the west, while in the western half they are practically horizontal.

The Edmonton formation consists of a series of shales and sandstones, often merely clays and sands, deposited during the period of brackish water which succeeded the marine invasion of the central part of the continent during early and mid-Cretaceous times. The formation is very rich in coal seams denoting periods of abundant vegetation. The coal-bearing beds of the Edmonton formation are exposed over an area of 30,000 square miles.

752 m. **Tofield**—Altitude 2,289 ft. (697m). To the
1,310 km. east and south of the junction of the Calgary

Miles and Kilometres.

branch with the main line, the low plateau facing north is underlain by a coal seam with an average thickness of nine feet (2·7m) overlain by a slight thickness of sandy shales, clay and boulder clay, or by the latter alone. On the property of the Tofield Coal Company the overburden is mainly shales and sandstones and the mantle of drift is quite thin, but on the Dobel property to the east the original cover is thinner but there is a greater thickness of boulder clay which includes detached and turned up rock masses of the original cover. The portions of the seam, where stripped by the glacial advance and re-covered with boulder clay, are much more weathered. Steam shovels and Lubecker excavators are used in removing the over-burden, and the coal is mined in open quarries.

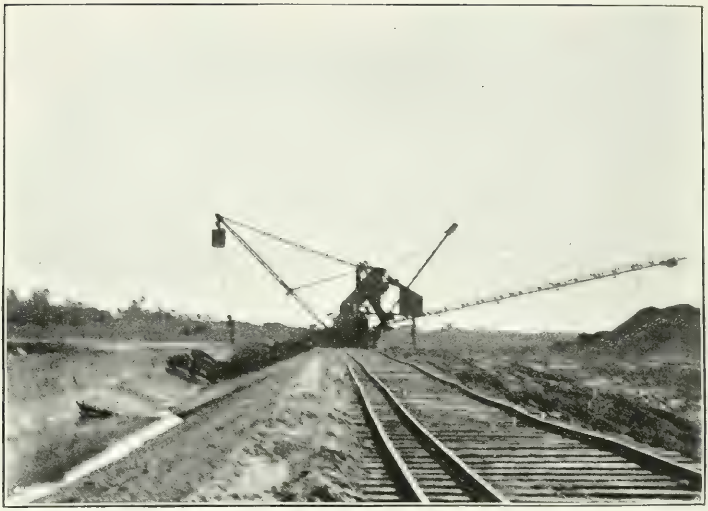
At the town of Tofield, where this seam is entirely eroded away, a boring was made down to the top of the Belly River formation. The following is a generalized summary of the section:—

		Feet.	Metres.
Edmonton	Shales and sandstones	200·0	60·90
	Coal	2·0	0·60
	Parting	1·5	0·33
	Coal	5·8	1·76
Pierre	Shale	740·6	225·10
Belly River	Coal	1·0	0·30
	Shales and sands	100·0	30·48
	Coal	4·0	1·21

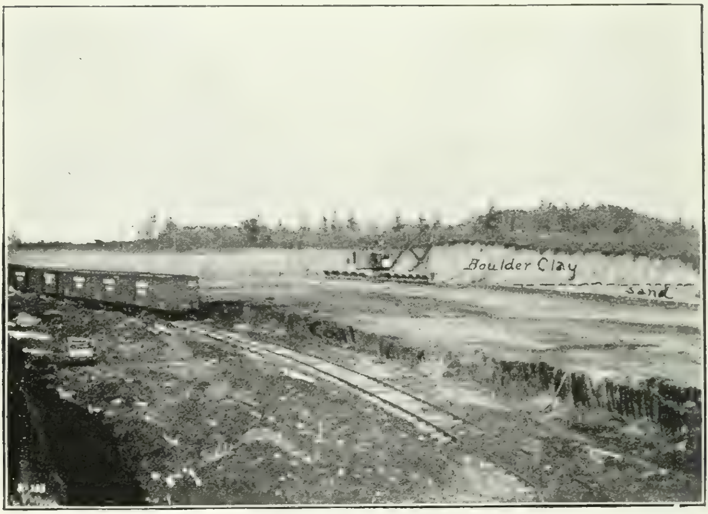
Just below the horizon of the lowest coal seam, gas and water were found. Further drilling operations are under way to thoroughly test the importance of the gas-bearing horizon.

793 m.
1,276 km.

Edmonton—Altitude 2,179 ft. (664 m.). Edmonton is situated on the Saskatchewan river 793 miles (1,276 km.) west of Winnipeg. The stream has cut a valley over 165 feet (50·4 m.) deep, the sides of which afford sections, at frequent intervals, of the Edmonton rocks. Workable coal seams outcrop at Clover Bar, 5 miles (8 km.) east of the city, and these con-



Lubecker excavator, Tofield Coal Co.



Steam Shovel, Dobel Coal Co.
Stripping coal at Tofield, Alta.

Miles and Kilometres.

tinue with slight westerly dip to the city itself. The seam has an average thickness of a little over 5 feet (1·5 m.). Between 15 and 20 feet (4·5 to 6 m.) below this seam there are evidences of another seam from 4 to 7 feet (1·2 to 2·1 m.) thick which may be distinct from that at Clover Bar. The coal is sub-bituminous, and is suitable for domestic and power purposes but requires care in shipment and storage.

Alluvial gold has for many years been washed from the bars in the Saskatchewan, both above and below Edmonton. Gravel dredged from the bed of the river is used extensively in road making. In the washing and crushing operations a small amount of gold is recovered daily.

837 m. **Wabamun**—Altitude 2,380 ft. (725 m.).
1,347 km. Westward to Wabamun the surface is gently rolling with an absence of outcrops of the underlying rocks. Between Wabamun and Fallis, on the north shore of Wabamun lake, the upper part of the Edmonton formation is exposed, the outcropping shale including a seam of sub-bituminous coal being reported to be from 18 to 22 feet (5·4 to 6·6 m.) thick with a small parting in the centre of the seam.

851 m. **Gainford**—Altitude 2,435 ft. (742 m.). The
1,369 km. coal seam outcropping on Wabamun lake dips to the west and is mined at Gainford at a depth of 138 feet (42 m) at which point it was found to have a thickness of 10 feet (3·04 m.).

859 m. **Entwistle**—Altitude 2,566 ft. (782 m.). The
1,382 km. valley of Pembina river, which is crossed at this point, is about 100 feet (30 m.) deep. A 10 foot (3 m.) seam of coal outcrops near the bottom of the valley, while upstream from Entwistle several other exposures show much thicker seams, one of which is stated to be 26 feet (7·8 m.) thick. These seams belong to the upper horizon of the Edmonton, in which coal is found in almost continuous beds from this point to Crowfoot, on the main line of the Canadian Pacific railway, a distance of 245 miles (390 km.).

Miles and
Kilometres.

932 m.
1,600 km. **Bickerdike**—Altitude 3,110 ft. (948 m.). A branch railway from this point runs south to the headwaters of Embarras and Little Pembina rivers, where the coal seams of the Edmomton formation are brought to the surface in the outer foothills. Mines are there in operation and are the forerunners of others to be opened later on the very rich measures of the Brazeau, which occur nearer the mountains. This field and its extension northward contains a very large reserve of both coking and steam coal. Other industries dependent on the transportation facilities afforded by the railway include a cement factory, situated at Marlborough, 8 miles (12·8 km.) west of Bickerdike. The materials used are marl from a lake basin and clay from a nearby sedimentary deposit.

958 m.
1,542 km. **Obed**—Altitude 3,560 ft. (1,085 m.). Surface deposits of this vicinity show erratics derived from the mountains to the west and possibly also from an eastern source, the latter, perhaps, having been transported westward by the Keewatin glacier. The elevation of the railway at this point is only 200 feet (61 m.) below that of the divide in the pass across the mountains.

978 m.
1,574 km. **Hinton**—Altitude 3,325 ft. (1,013 m.). To the north can be seen the valley of Athabaska river flanked by terraces, on one of which the railway has been built. The rocks of the Edmonton series, which to the east of this point dip at low angles, or lie nearly flat, here have an easterly dip. Westward this dip increases and the strata become folded and faulted to such an extent that the region has been termed the "disturbed belt" of the foothills.

Brulé lake—For about six miles (9·6 km.) the railway follows the eastern shore of Brulé lake, which is a shallow basin gradually being silted up by the detritus carried down from the mountains by the Athabaska river. Inside the mountains other portions of the valley show the completion of this process of silting up and the incision of a channel across the basins.

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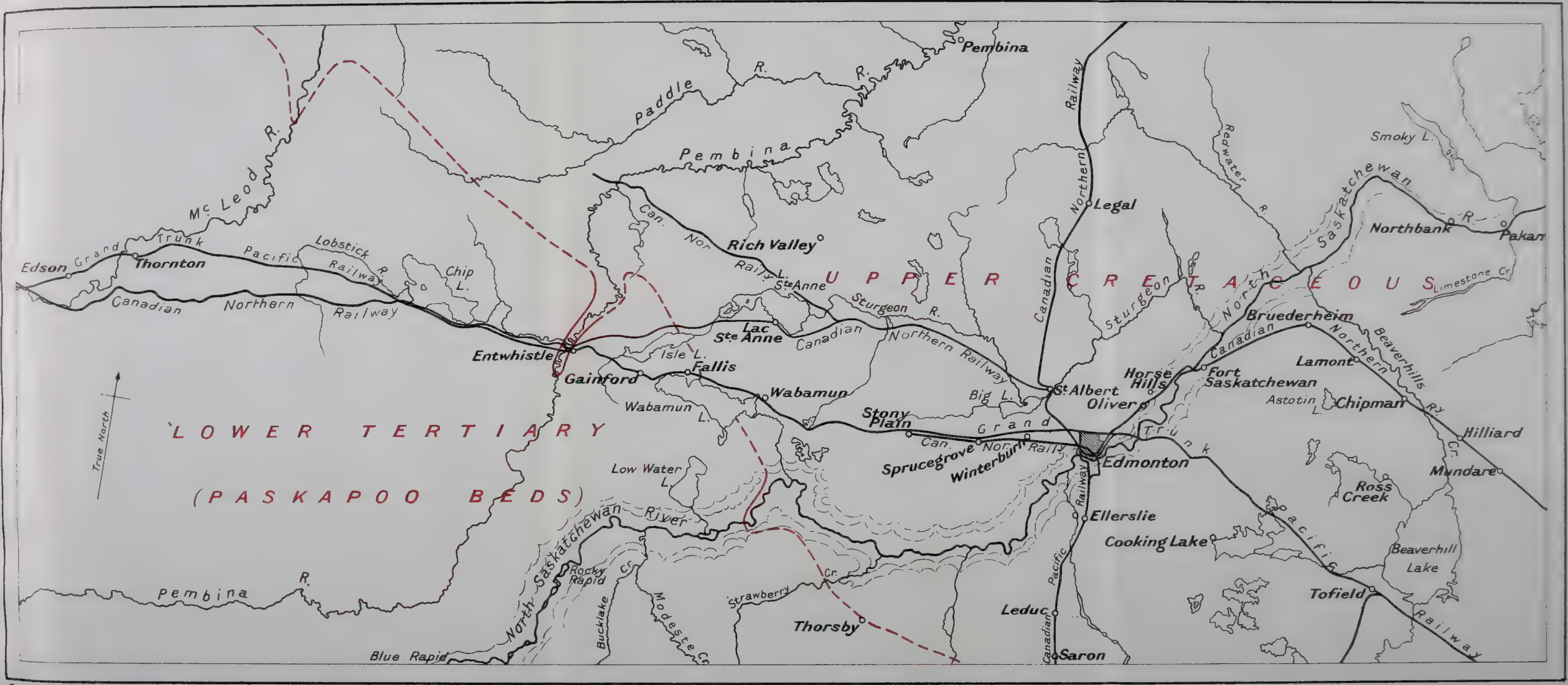


Geological Survey, Canada

Route map between **Edmonton** *and* **Edson**

Miles: 5 0 10 20 30 40

Kilometres: 5 0 10 20 30 40 50 60

Miles and Kilometres.

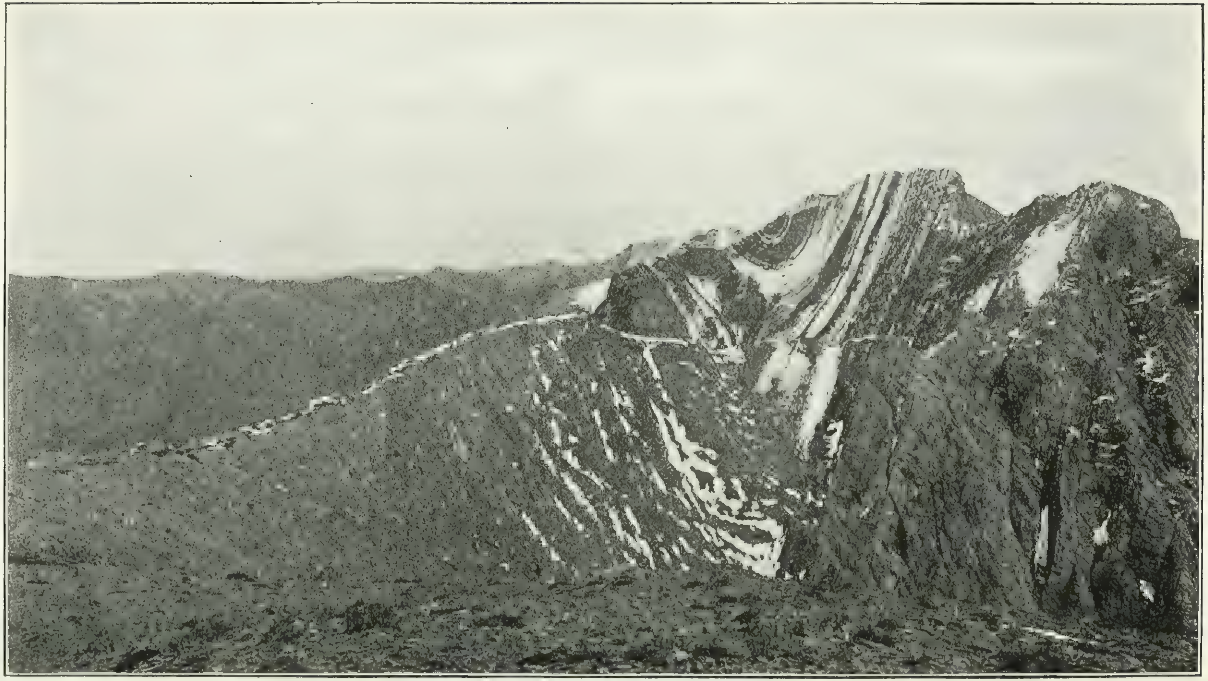
The first or outer range of the Rocky mountains stands out prominently on the western side of Brulé lake, and the structure there displayed is that of an overthrust block of Devonian limestone superposed on Lower Cretaceous.

ROCKY MOUNTAINS.

The fault block system of mountain building observed in the southern sections of the Rocky mountains is modified in this section by the substitution of sharp folding for minor faulting, and the blocks between the major faults show complex folds in the beds and are much wider. Two large blocks, whose elevated eastern edges form Roche Miette and Bulrush mountain, exhibit this folding, while the valley depression between the two is underlain by Lower Cretaceous rocks containing coal. Mines are being established on both sides of the valley. The lowest rocks outcropping here are of Cambrian age and underlie a series of sediments capped by fossiliferous Devonian limestone, which is exposed in the cliff of Roche Miette. The Cambrian rocks are disposed in a yellow band near the fault line which separates the lower rocks from the Cretaceous. The succeeding fault blocks are tilted, but not folded, and in that respect resemble the mountains to the south.

The structural section of the mountains on the Athabaska shows a modification in the outer ranges of the fault block system exhibited on the southern passes. The outer blocks have been deformed by sharp folds, which when traced southward develop into faults, and separate the block into several smaller blocks. Two of the blocks showing this contortion are seen from Pocahontas station. The eastern one of these has its uplifted edge fronting to the east on Brulé lake: the second forms Roche Miette, the depressed edge being beneath the valley of Rocky and Stony rivers. Cretaceous beds are found at the back of the first block; some of these beds may also remain on the second, but they are masked by the great deposit of detrital matter in the two valleys mentioned.

The rocks forming these blocks include a series of sediments ranging in age from Lower Cretaceous downward to Upper Cambrian, all in apparent conformity. The lowest sediments are at the base of the second block. The character of these beds is outlined below:—



Folds in Outer range south of Athabaska river.

Cretaceous.—Rocks of this age include sandstones and shales of about the horizon of the Kootenay formation, and contain plant remains and coal seams. Fresh water conditions are indicated, although in the lower part, salt water deposits are not wanting. Of the plant remains the following have been collected in this locality:—

Podozamites lanciolatus, *Sequoia richenbachii*, *S. smittiana*, *Oleandra gramniaefolia* and *Zamites acutipennis*.

Jurassic.—This formation is made up mostly of black shales holding *Belemnites*. Included in it are two sandstone ribs, the upper with *Arctica occidentalis* and *Nemodon sulcatinus*, and the lower, lying practically at the base of the formation, shows remains of *Gryphaea planoconvexa*, *Ostrea strigicula* and a species of *Terebratulina*.

Triassic and Permian.—Some reddish shales and dolomites resting on yellow to brown shales and quartzites have been referred to these periods, but have not been examined in detail.

Carboniferous.—In the Banff section the Carboniferous limestone forms a prominent heavy bed. Northward this formation thins considerably, and is here represented by thin bedded limestones, and possibly by some of the quartzitic layers mentioned above.

Devonian.—The heavy limestone beds, which form the outer mountains, appear to be mostly of this age. Two limestone beds appear, in the upper of which both Devonian and lower Carboniferous fossils occur, but the line of demarcation between these two periods has not been determined. Typical Devonian fossils are plentiful in the lower limestone which forms the block of the top of Roche Miette.

Silurian.—Shaly beds at the foot of Roche Miette may possibly belong to this age, but no fossils except species of *Stromatopora* have been found in them.

Cambrian.—Near the base of the series forming the mass of Roche Miette, a yellow band is exposed near the fault line which separates the lower rocks from the Cretaceous. In this yellow band the following trilobites have been collected:—*Crepicephalus iowensis*, *Ptychoparia affinis* and *P. wisconsinensis*.

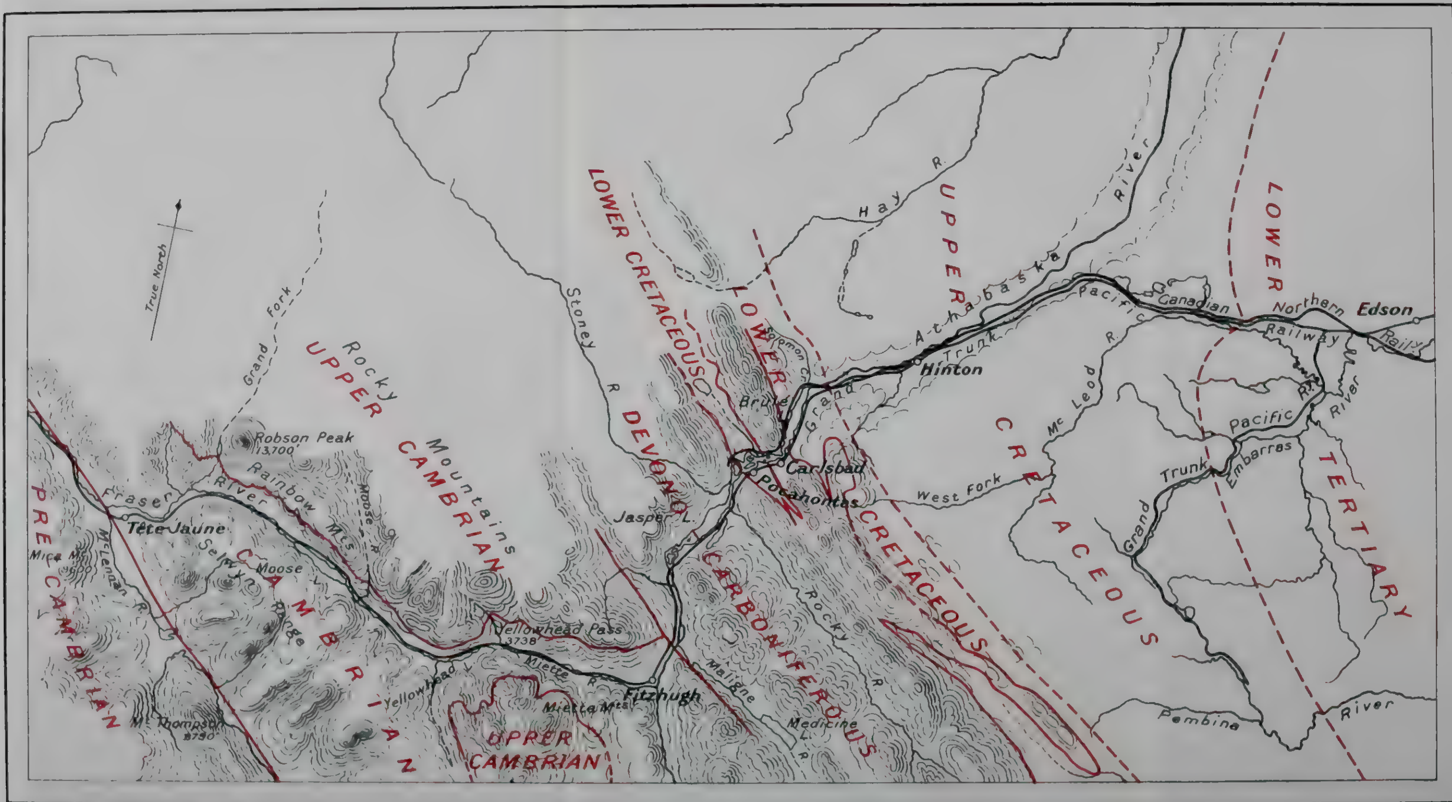
Miles and Kilometres.

1,001 m. 1,611 km. **Pocahontas**—Altitude 3,282 ft. (1,000 m.). This station is opposite the Cretaceous portion of the outer fault block mentioned above. The Cretaceous beds, however, are not well exposed. A conglomerate band is easily traced on the opposite bank of the river, where it is seen in the fold which traverses the coal field. The coal seams here are above the conglomerate band and are mined in the western trough at this station. The mine entry is on the strike of a 10-foot (3 m.) seam.

1,027 m. 1,652 km. **Fitzhugh**—Altitude 3,457 ft. (1,057 m.). The mountains between Rocky and Snaring rivers are of the block type and are built of Devonian and Carboniferous limestone. The line of fault separating the younger ranges from a wide block which has evidently suffered a much greater upthrust, is passed before reaching Fitzhugh, a new town on the site of an old trading post established by the Northwest Trading Company in 1881 but long since abandoned. The throw of this fault is measured in thousands of feet, since the highest beds remaining in this block were beneath the limestone of the outer ranges. The structure to the west is somewhat similar to that at the summit on the Kicking Horse pass to the south. The valley of Miette river is denuded on the line of a local sharp fold or break.

1,044 m. 1,790 km. **Yellowhead**—Altitude 3,724 ft. (1,135 m.). The rocks exposed along the Miette river are a coarse quartzite and fine-grained conglomerates, which have been in places squeezed out to show schistose structure. Interbedded with these are greenish grey slates, and beneath, a few small exposures show dark argillites and thin-bedded calcareous sandstones.

Yellowhead mountain to the north shows, above the conglomerates and quartzites of the



Geological Survey, Canada

Route map between **Edson** and **Tête-Jaune**

Athabaska river and Outer range, Rocky mountains.

Jasper lake, Athabaska river from Roche Miette.

Miles and Kilometres.

lower slopes, a series of yellowish weathering crystalline dolomites which probably represent the Castle mountain series of the Laggan section to the south.

Fraser river is incised in the rocks of the lower part of these Cambrian sediments, and the mountains to the west seem to have little of the upper series on their summits. The structure of the mountains at the watershed is that of a shallow syncline of the coarse grained siliceous detrital matter, their lower slopes showing finer grained deposits of the Bow River series, while their summits preserve the dolomites of the Castle Mountain series.

1,079 m. 1,736 km. **Mount Robson station**—Altitude 3,106 ft. (947 m.). Mount Robson, viewed from the Fraser valley, towers high above the neighbouring mountains. Its beds are flat lying and show a section of nearly 10,000 feet of strata. These strata form the subject of a special enquiry by C. D. Walcott of the Smithsonian Institution.

1,095 m. 1,762 km. **Tete Jaune**—Altitude 2,400 ft. (731·5 m.).

TOFIELD TO WINNIPEG.

Introduction.

Tofield is 752 miles (1,209 km.) west of Winnipeg and stands at an elevation of 2,289 feet (697 m.) above sea level.

Between Tofield and Winnipeg the railway traverses a rolling or level prairie country underlain by horizontal or gently inclined Cretaceous and Palæozoic rocks. The following are the formations represented:—

Cretaceous { Edmonton series. Belly River series. Pierre shales.

Devonian.
Silurian.
Ordovician.

The country generally is so covered by a veneer of glacial drift that accurate boundaries between geological series can rarely be laid down. The Edmonton series ex-

Mount Robson from Grand Forks, Fraser river.

tends as far east as Ryley. From this point to Oban, the country is underlain by the Belly River series. The Eagle hills in the vicinity of Oban, may be topped by a slight thickness of Tertiary rocks. The Pierre shales extend from Oban to east of Caye. They are subdivided into the upper or Odanah and the lower or Millwood shales, the latter being very fossiliferous in the vicinity of Uno.

From Caye station eastward to Winnipeg and beyond, the Devonian, Silurian and Ordovician rocks are buried under the silts forming the bottom of glacial Lake Agassiz.

Between the east border of the Eagle hills and Young station, the railway traverses the bottom of glacial Lake Saskatchewan, a probable contemporary of Lake Agassiz. The lake was comparatively short lived, as evidenced by the absence of well marked terraces or beaches.

Annotated Guide.

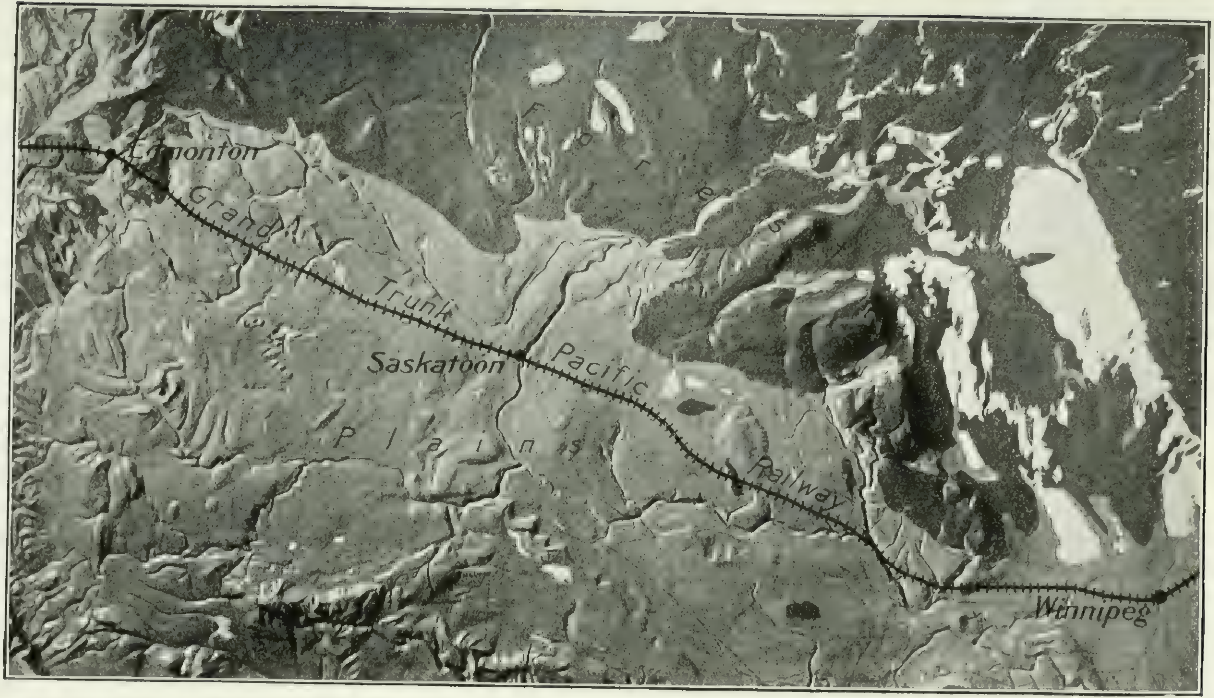
Miles and Kilometres.

752 m. 1,209 km. **Tofield**—Altitude 2,289 ft. (697 m.). The Edmonton series of clays dips to the west and may extend east to Ryley. Beyond Ryley the surface is covered by drift containing considerable sand derived from the Belly River series probably exposed east of Bruce.

703 m. 1,131 km. **Phillips**—Altitude 2,294 ft. (695 m.). Just east of Phillips the cuttings in the drift indicate the underlying sandy deposits. From here to Kinsella, boulder clay predominates, and the surface of the country is irregularly hilly.

678 m. 1,090 km. **Hawkins**—Altitude 2,126 ft. (647 m.). Several heavy cuts on the north side of Grattan creek show a section in the Belly River series consisting, in descending series, of light yellow sandstones with occasional brown streaks containing plant remains accompanied in some places by thin seams of lignite, greyish green shaly sands with brown ironstone nodules. In the valley of Battle river, a harder sandstone outcrops at a lower horizon and forms a slight bench on both sides of the valley.

667 m. 1 075 km. **Wainwright**—Altitude 2,213 ft. (673·4 m.). The underlying rocks are mostly of a sandy nature similar to those at Battle River crossing.



Relief map of the Great Plains.

Miles and Kilometres.

The surface drift is consequently sandy in character, and true sections are not seen until Manitou lake is reached.

South of the track at Wainwright the Canadian government has reserved nearly 144 square miles (37,762 hectares) for the maintenance of a herd of 1,217 bison (1912) commonly known as buffalo. The experiment appears to be successful and the herd is increasing; 220 calves are reported for 1912.

618 m. 994·4 km. **Zumbro**—Altitude 2,051 ft. (625 m.). Between Zumbro and Yonker the railway follows the south shore of Manitou lake. The cut banks seen in the distance consist of the light coloured sands of the upper portion of the Belly River series. The basin is part of a former drainage channel into which several minor channels converge.

585 m. 941 km. **Unity**—Altitude 2,087 ft. (636 m.). From Vera to Unity the railway traverses an old channel leading to Manitou lake, narrowing to Unity, where the general prairie level is gained. The plateau marks the approximate top of the Belly River series, the terrace lying to the north being probably underlain by Pierre shales. From Unity the railway runs along the foot of a slight escarpment which marks the northern edge of the Belly River rocks, that occasional cuts show to consist mostly of yellow sands.

569 m. 915·5 km. **Scott**—Altitude 2,159 ft. (660) m.). South of Scott an old drainage channel marks the extreme end of the Eagle Hill creek drainage basin. Eastwards between Reford and Coblentz the cuttings show heavy deposits of boulder clay.

535 m. 861 km. **Oban**—Altitude 2,120 ft. (646 m.). Two miles (3·2 km.) west of Oban dark shales outcrop and probably lie above the Belly River. From Oban eastwards to Mead, the country is rolling and constitutes the Eagle Hill belt, possibly underlain by Tertiary rocks. East of Mead the surface is very uniform and is underlain by sandy shales which suggest a

Miles and Kilometres.

light veneer of lower Tertiary continuing for some distance to the east. This plain is supposed to have been a glacial lake basin, known as Lake Saskatchewan, occupying part of the valleys of the North and South Saskatchewan and blocked or dammed to the northeast by the retreating Keewatin ice sheet. The existence of this lake, as inferred from the silts covering the surface, was not of long duration, since no strongly marked beaches are apparent. Milepost 478 marks the western edge of the flat country west of the Saskatchewan valley and may also mark the western limit of the glacial lake at its lowest stage in this latitude.

467 m.
751·4 km. **Saskatoon**—Altitude 1,665 ft. (507 m.). Saskatoon is situated on both sides of the Saskatchewan valley. Eastwards to Young, the country is flat with little evidence to show the character of the underlying rocks. The few cuttings show sandy clay with very few boulders.

422 m.
679 km. **Young**—Altitude 1,714 ft. (522 m.). Near the station there appears to be a possible outlet valley to the southeast for the glacial Lake Saskatchewan. This valley appears to join the deep valley occupied by Lost Mountain lake, which is a tributary of the Qu'Appelle. The difference in elevation between Young and Lost Mountain lake is 118 feet (35·8 m.) and if the drainage was southwards at any time it was of short duration otherwise it would be expected that the valley of Lost Mountain would have deepened itself further to the north.

The deep valley of the tributary of the Qu'Appelle lying west of the foot of Lost Mountain lake and extending to the elbow of the South Saskatchewan, marks the old main channel of the latter river when it flowed eastwards through the length of the present Qu'Appelle valley.

408 m.
656 km. **Watrous**—Altitude 1, 781 ft. (543 m.). The position of the front of the Keewatin ice sheet during a pause or a series of advances and

Miles and Kilometres.

retreats is indicated between Young and Watrous, a distance of 14 miles (22·4 km.), by a series of morainic hills of boulder clay of drumlin-like form with a trend to the northeast.

372 m.
598 km.
Semans—Altitude 1,844 ft. (562 m.). At Semans the bare plains are left behind and hilly country is entered which is fairly well wooded. The surface veneer is more or less of boulder clay and is rather thin. At Punnichy 20 miles (32 km.) to the east, the exposures appear to be the top of the Pierre shales or the Foxhill from the yellow sandy clays which outcrop near Touchwood station. Just west of Touchwood, the railway follows a series of lake basins that appear to be in an old and abandoned valley. The country is fairly open to Melville.

265 m.
426 km.
Waldron—Alt. 1,739 ft. (530 m.). Waldron lies near the edge of the wooded country which the railway enters in part and in part follows the southern edge. Welby is the last station in Saskatchewan and is situated on the plateau above the Qu'Appelle. From here the line descends along the side of the valley to the bottom land of the Assiniboine river passing Lazare at the confluence of the two streams.

186 m.
299 km.
Uno—Altitude 1,370 ft. (427 m.). One mile (1·6 km.) east of Uno station, the Millwood shales outcrop along the side of the Assiniboine valley and continue east to the crossing of Birdtail creek. The shales are dark grey in colour with ironstone nodules referred to the lower part of the Pierre.[a]

The fossiliferous beds contain *Baculites compressus*, *Pteria linguiformis*, *Inoceramus tenuilineatus*, *Inoceramus sagensis*, *Nucula*, *Lucina occidentalis*, *Entalis paupercula*, *Scaphites nodosus*, *Hylobiites cretaceus* and some 15 species of *Radiolaria*.

Arrow River—A short distance east of the station several cuttings show a light grey shale which is probably the Odanah.

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[a] Tyrrell, J. B., Geol. Surv. of Can., Vol. V, 1890-91, p. 213 E.

Miles and Kilometres.

Rivers—The railway crosses the terraced valley of the Little Saskatchewan.

121 m. 195 km. **Justice**—Altitude 1,430 ft. (436 m.). The boulder clay is overlain by lake and delta silts marking the western limits and high water level of the glacial Lake Agassiz. At Ingelow eight miles (12·8 km.) to the east the first beach or evidence of shore line appears.

54 m. 87 km. **Portage la Prairie**—Altitude 850 ft. (259 m.). The railway here traverses the bottom lands of glacial Lake Agassiz and continues to Winnipeg.

0 m. 0 km. **Winnipeg**—

WINNIPEG TO COCHRANE VIA NATIONAL TRANSCONTINENTAL RAILWAY.

INTRODUCTION.

BY

W. H. Collins and M. E. Wilson.

The distance from Winnipeg to Cochrane by way of the National Transcontinental railway is 780 miles (1,255 km.) The route lies over flat-lying Palæozoic sediments of the interior plains region for the first 50 miles (80 km.), and then enters upon the Pre-Cambrian shield, which is continuous for the remainder of the distance. For 55 miles (88 km.) east of Winnipeg, the Palæozoic beds and their junction with the Pre-Cambrian are completely concealed by the alluvial deposits of glacial Lake Agassiz. Again near Lake Nipigon the Pre-Cambrian bed rock is largely hidden beneath stratified sand and clay laid down in a great bay of the extinct glacial Lake Warren which formerly occupied the present basin of Lake Nipigon. And in the region lying between Kenogami river and Cochrane, the Pre-Cambrian rock surface is almost completely buried beneath the lacustrine clay of Lake Ojibway.

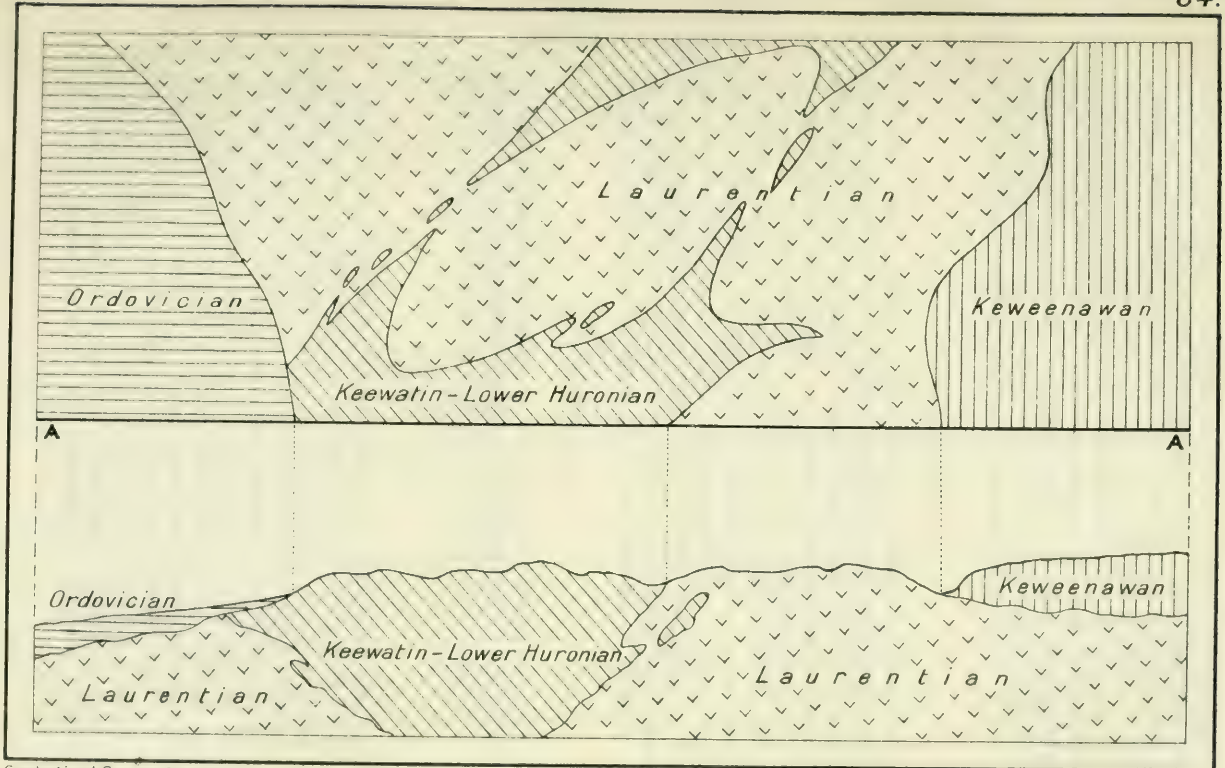
The rocks of this region may be separated into five main groups, distinct from one another in age, lithological character, and in their structural relationships as expressed in the accompanying diagram.

KEEWATIN AND LOWER HURONIAN

This oldest group is a highly metamorphosed complex consisting of a variety of acid and basic eruptives and minor amounts of banded iron formation (Keewatin); and a younger sedimentary series of conglomerate, greywacke, slate with local iron formation phases, and associated eruptives (Lower Huronian). These have endured at least one orogenic disturbance which folded them and converted them into highly inclined schists. Granite batholiths, which were intruded at probably the same period, have further metamorphosed them near their contacts to crystalline, hornblende gneisses, amphibolites, mica schists, etc. But, away from the batholithic contacts, where metamorphism has been less intense, the ellipsoidal, amygdaloidal, and other structures of the Keewatin volcanics and the stratification of the Huronian sediments are still sometimes recognizable. An unconformity exists between the Keewatin and Lower Huronian, but so profoundly has it been modified by these metamorphic changes that its importance can not be satisfactorily estimated; in fact it is usually difficult to recognize. In later Pre-Cambrian time, protracted erosion unroofed the granite batholiths and removed all except the synclinal portions of this folded Keewatin-Lower Huronian group leaving it distributed much as it is today [**7** and **23**].

LAURENTIAN.

This term is applied broadly to all granites and gneisses in the region. As indicated in the diagram, the Keewatin-Lower Huronian areas form a rude meshwork, the interspaces of which are occupied by more or less distinct, oval areas of gneiss and granite, that probably represent individual batholithic domes. These rocks are dominantly granodiorites, though granites and syenites are also present. A gneissic texture is more common than a granitic one, particularly in granodiorite facies. Also, near contacts with the Keewatin-Lower Huronian complex, the gneiss contains a varying quantity of these older materials which have been stoped off and floated out into the granite magma while the latter was still plastic. The distribution and character of these inclusions would imply that the gneissic structure of the enclosing rock also was



Geological Survey, Canada.

Figure I. Diagram showing geological relationships in the region between **Lake Nipigon** *and* **Winnipeg**, *with a diagrammatic* **Section** *along the* **Line A-A**

developed during a state of plasticity. Some of the inclusions retain their angular shapes, some are rounded, and others have been drawn out into thin ribbons by magmatic movements. They are always notably crystalline, being chiefly hornblende gneiss, amphibolite, or biotite gneiss. The "transition zone" thus developed in the Laurentian near its contacts with the older rocks varies in width from a few yards to five miles (8 km.) and merges by reduction of the inclusions into ordinary Laurentian gneiss.

KEWEENAWAN.

Near Lake Nipigon the greatly dissected Keewatin-Lower Huronian and Laurentian surface is unconformably overlain by a sedimentary series consisting of a thin basal conglomerate, sandstone, and impure ferruginous dolomite. The dolomite is usually bright red in colour and contains disseminated gypsum and traces of salt crystal casts. These formations, which are Keweenawan in age, are almost flat-laying and little metamorphosed. They have been intruded by somewhat later dykes and thick sills of diabase similar to the ore-bearing diabases of Cobalt district and the south shore of Lake Superior [**7**; **12.**].

ORDOVICIAN.

The eroded Laurentian surface of the western part of the region is also unconformably overlain by undisturbed sandstone and impure limestone of Ordovician age [**9**].

PLEISTOCENE.

All of the preceding solid rocks are glaciated and are overlain by a thin mantle of unconsolidated gravel, sand, boulders and boulder clay, materials which were laid down in association with the Pleistocene continental glaciers. These glacial and fluvio-glacial deposits are in turn overlain, by stratified clay, sand and gravel deposited in the previously mentioned glacial lakes, Agassiz, Warren and Ojibway. All three of these lakes are believed to have been dammed on the north by the waning ice sheet.

Lake Agassiz was a vast body of water which extended throughout nearly the whole of southern Manitoba as well as the adjacent portion of Minnesota, North Dakota,

Manitoba and Saskatchewan. The total area covered by the lake during the various stages of its existence has been estimated to have been not less than 110,000 square miles (275,000 sq. km.). The deposits laid down in the deeper parts of the lake consist of a thin layer of clayey silt but along the shore, gravel and sand were built up to a thickness of—in some of the deltas—50 to 200 feet (15 to 60 m.) [**20; 21**].

The post-glacial deposits around Lake Nipigon were laid down in Lake Warren, the largest of the lakes which occupied the upper part of the St.Lawrence basin following the retreat of the Labradorean ice sheet. A northern bay of this lake covered a wide area of country in the vicinity of Lake Nipigon. The deposits from this bay of Lake Warren are found along the railway between Wagaming and Ombabika bay, a distance of 30 miles (48 km.). They consist of stratified sand underlain by clay and have a thickness of approximately 100 feet (30 m.) (**6**) (**14**) (**22**).

The third area of lacustrine deposits traversed by the railway, were laid down from a lake which lay for the most part in the southern part of the James Bay basin but also extended across the St. Lawrence-Hudson Bay divide into the Ottawa basin, for, in northwestern Quebec, the lacustrine clays have been traced continuously from Lake Timiskaming to points north of the divide. For this body of water the name Lake Ojibway has been suggested by A.P. Coleman. The areal extent of its deposits have not yet been precisely ascertained but they are known to occur throughout an area of at least 50,000 square miles (125,000 sq. km.). They occur almost continuously along the National Transcontinental railway from the crossing of the Kenogami river to Cochrane a distance of 320 miles (515 km.), and to the eastward of Cochrane for a distance of 210 miles (350 km.),—a total extent from east to west along the railway of 530 miles (853 km) (**9**). They consist largely of uniformily stratified clays or clay and sand and for that reason the region throughout which they occur is known generally as the "clay belt." Their thickness is nowhere very great the maximum recorded in the cuts along the National Transcontinental railway being only 26 feet (7·9 m.). [**1, 2, 3, 5, 10, 11, 13, 26, 27**].

TABULAR RESUME.

The major events in the geological history of this region so far as they have been interpreted may be summarized as follows:—

Time.	Event.
Keewatin	Protracted vulcanism, with minor deposition of banded iron formation and other obscure sediments.
	Unconformity, erosion and probably batholithic intrusion.
Lower Huronian	Deposition of conglomerate, greywacke and slate with contemporaneous vulcanism.
Laurentian	Orogenic disturbance of Keewatin and Lower Huronian rocks, with intrusion of granite batholiths.
	Great unconformity; peneplanation.
Keweenawan	Deposition of conglomerate, sandstone and dolomite; later intrusion of diabase sills.
Ordovician	Marine submergence and deposition of impure limestone in the western part of the region.
	Unconformity.
Pleistocene	Glaciation, formation of glacial lakes, ice retreat.

ANNOTATED GUIDE.

Winnipeg to Nipigon.

BY

W. H. Collins.

Miles and Kilometres.

o m.
o km.

Winnipeg—Altitude 763 ft. (232·7 m.). For 55 miles (88 km.) east of Winnipeg the railway pursues a direct course across flat prairie country, almost treeless for the first 25 miles (40·2 km.), but becoming more and more thickly forested as the Pre-Cambrain shield is approached. This is the bed of glacial Lake Agassiz. The slight amount of excavation required by railway construction in this alluvial plain, whose local relief does not exceed 20 feet 6·5 m.), nowhere exposes the Ordovician bed rock. It only shows from one to four feet

Miles and Kilometres.

(3 to 1·2 m.) of black vegetable mould overlying poorly assorted, boulder clay or yellow mud.

Red river is crossed at the outskirts of Winnipeg.

5·4 m. 8·6 km. **Transcona**—Altitude 758 ft. (231·1 m.). The workshops and terminal yards of the Grand Trunk Pacific railway are situated at Transcona.

31·0 m. 49·6 km. **Vivian**—Altitude 891·5 ft. (271·8 m.). The monotonous flatness of the prairie is broken just west of Vivian by a low, flat-topped ridge through which the railway has made a cut 12 feet (3·9 m.) deep and 150 feet (45 m.) long. The gravel and sand composing this ridge are cross-bedded, and the larger pebbles have the the flattened shapes of beach shingle. While it has not been more carefully investigated and its extent north and south of the railway is unknown, this ridge is thought to be an old Lake Agassiz beach.

56·2 m. 89·9 km. **Elma**—Altitude 921 ft. (280·9 m.). The first outcrop of Laurentian gneiss is seen just west of milepost 56.

65·3 m. 104·5 km. **Hoctor**—Altitude 999 ft. (304·7 m.). Between milepost 60 and Hoctor the flat alluvial lake bottom gives place to the rocky Pre-Cambrian region. Low masses of rock protrude more and more frequently through the flat swamps and muskegs, and occasional lakes, so characteristic a feature of the Pre-Cambrian region, appear. The rocks exposed here and for the the next 165 miles (274 km.) are all Laurentian gneisses or "transition zone" mixtures of Laurentian gneiss and Keewatin inclusions.

The Canadian Pacific railway is crossed at ·65 miles (1·0 km.) east of milepost 69.

99·3 m. 158·9 km. **Malachi**—1,082 ft. (330· m.). Between White and Malachi, the gneiss contains a large proportion of Keewatin inclusions ranging in form from angular blocks to slender ribbons. From milepost 80 to milepost 84 the proportion of Keewatin material (hornblende gneiss) increases to 75 per cent and is traversed only by dykes and stringers of Laurentian granite and

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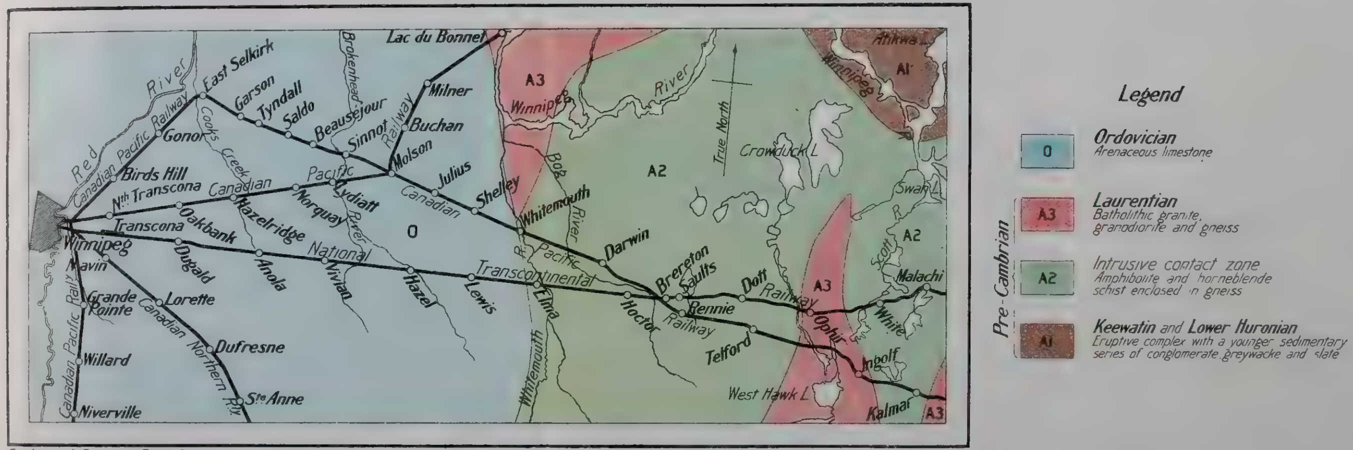
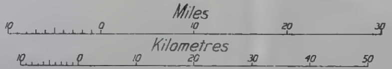


Geological Survey, Canada

Route map between **Malachi** and **Winnipeg**



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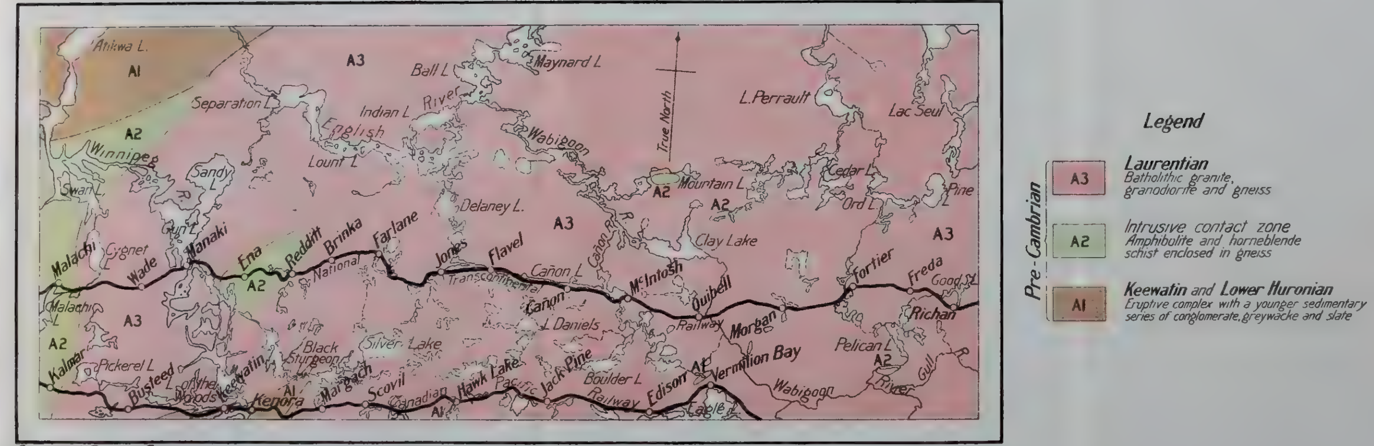
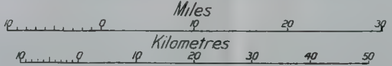


Geological Survey, Canada.

Route map between **Richan** and **Malachi**



Miles and Kilometres.

pegmatite. The various stages in magmatic stoping are well illustrated in this interval.

115·2 m. 184·3 km. **Minaki**—Altitude 1,048 ft. (319·6 m.). Winnipeg river, the largest stream crossed by this section of the railway, is crossed just east of milepost 115.

129·4 m. 207 km. **Redditt**—Altitude 1,071 ft. (326·6 m.). Between milepost 149 and 152 the gneiss has been sliced into thin parallel plates from an inch (2·5 cm.) to several feet (1 m.) in thickness, apparently as a result of yielding to stresses.

168·9 m. 271·9 km. **McIntosh**—Altitude 1,228 ft. (374·5 m.). From milepost 154 to milepost 169 the railway follows the south shore of Cañon lake, a typical example of the rocky lakes characteristic of the Pre-Cambrian region. The country here is unusually rugged and a number of short tunnels occur on the railway.

177·4 m. 283·8 km. **Quibell**—Altitude 1,178 ft. (359·2 m.). During Glacial time portions of Wabigoon River valley were probably ponded and received deposits of stratified clay similar to those laid down in the larger glacial lakes. This lacustrine deposit first appears on the railway near milepost 172, where the boulder clay changes in somewhat transitional manner to stratified clay. From this point to milepost 185 the finely laminated clay is almost continuous; between mile posts 175 and 181 it forms a comparatively level plain, resembling, on a small scale, the prairie region of the west.

206·4 m. 330·2 km. **Richan**—Altitude 1,285 ft. (391·9 m.). Laurentian gneiss is again abundantly exposed from the eastern edge of this clay deposit to milepost 224, where it becomes obscured by glacial materials.

At ·4 mile (·6 km.) east of milepost 223 a deep cut has been made in a hill of imperfectly stratified sand and gravel.

231·7 m. 470·7 km. **Webster**—1,234 ft. (376·3 m.). Between mileposts 217 and 234 the route skirts the northern margin of a terminal moraine and outwash deposit which extends southward. The country north of the railway is scantily clad

Miles and Kilometres.

with soil. As the train approaches milepost 232 a good view is obtained of an esker-like ridge laid down apparently by a southward flowing englacial stream. The forest in this vicinity has been fire-swept, and the sinuous course of the ridge may be easily observed for nearly a mile to the north. Farthest away it is a low ridge of coarse boulders, but, approaching the railway, it grades successively into gravel and sand, becoming higher and broader at the same time. Where the railway cuts through it to a depth of 40 feet (12·2 m.), it consists of convexly bedded and cross-bedded sands, through which are scattered occasional large boulders. South of the track it merges into the terminal moraine already mentioned. The course of this glacial stream was evidently independent of the topography of the ice-covered country, for the deposit which marks it winds up a steep slope to the railway. A small kettle lake on the south side of the railway can be seen from the same point.

Schists of the Keewatin-Lower Huronian group are seen first near milepost 236. For 29 miles (46·4 km.) eastward from this point, the railway runs near the northern margin of a large area of these rocks, crossing at irregular intervals tongues of Laurentian, which are intrusive into it from the north. But, for most of this distance, the rocks are poorly exposed.

Intrusive dykes and tongues of granite are especially common between mileposts 236 and 250. Ordinarily the Laurentian is strongly gneissic at its contacts with the Keewatin, and includes a large proportion of fragments of the older formation. Less frequently the magma seems to have been more fluid and crystallized as massive granite, nearly free from xenoliths. The contacts in this vicinity are of the latter type. At ·25 mile (·4 km.) east of milepost 249, for example, granite is in sharp contact with an overarching chloritic schist. The granite in this and similar cases approximates more or less closely in composition to a true

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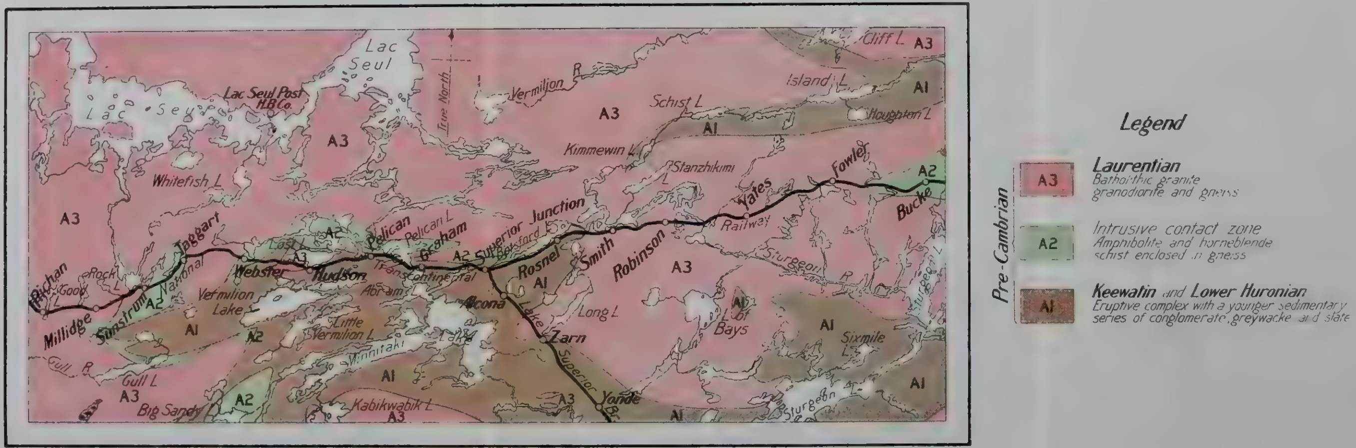

Geological Survey, Canada

Route map between **Bucke** and **Richan**

Miles

10 0 10 20 30

Kilometres

10 0 10 20 30 40 50

Miles and Kilometres.

granite; a granodioritic composition appears to be more characteristic of gneissic phases of the Laurentian, which contain partly assimilated Keewatin inclusions.

The spur leading southward from the main line near Pelican connects with a mine on Vermilion lake, where a large vein of pyrite is being developed.

252 m. **Graham**—Altitude 1,189·4 ft. (362·6 m.).
403·2 km. Between Graham and Superior the schists are covered by stratified clay similiar to that seen in Wabigoon valley and probably laid down in a former expansion of Sturgeon river. The rocky banks farther upstream show numerous large potholes from 10 to 15 feet (3 – 5 metres) above the present level of the river, indicating its former volume to have been much larger than the present one. A narrow belt of closely folded Lower Huronian conglomerate and greywacke follows the course of Sturgeon river, but is hidden beneath the stratified clay, where the railway crosses the river just west of Superior.

258·4 m. **Superior**—Altitude 1,190 ft. (362·9 m.).
413·4 km. Keewatin schists give place to the Laurentian gneiss near Rosnel. Keewatin rocks are once more traver-

267·9 m. **Rosnel**—Alt. 1,180 ft. (359·9m.) sed in the
428·6 km. next 51 miles

(81·6 km.), but there is little of geological interest to be seen in this distance. At the Laurentian-Keewatin contact, 3·7 miles (5·9 km.) east of Staunton, the schists are derived from acid eruptives and exhibit much less contact metamorphic effects than is the case with basic materials where so close to the Laurentian intrusives.

The greatest elevation (1,457 ft. 444·1 m.) on the railway between Winnipeg and Lake Nipigon is attained 3 miles (4·8 km.) east of Bucke.

312·4 m. **Bucke**—Altitude 1,401 ft. (427·3 m.). The
499·8 km. first erosion remnant of Keweenawan diabase is passed 2 miles (3·2 km.) east of Harvey. Such vestiges of diabase sills become larger and

Miles and Kilometres.

more numerous as the main Keweenawan area around Lake Nipigon is approached. They have a pronounced columnar and parallel jointing, which gives rise in them to a much more precipitous relief than is seen in the Laurentian.

334·9 m.
535·8 km. **Allen Water**—Altitude 1,332 ft. (4,062 m.). Between Kawa and Allen Water river, the gneiss contains numerous angular and ribbon-like inclusions of hornblende gneiss, derived from the Keewatin.

About a mile and a half (2·4 km.) west of Kawa, Keweenawan diabase may be seen lying directly upon Laurentian gneiss. At this point, on the north side of the railway, a cliff of diabase rises abruptly from a comparatively flat Laurentian floor.

362·4 m.
579·8 km. **Ogoki**—Altitude 1,273 ft. (388·2 m.). From Cameo to Ogoki the forest has been burned, the gneiss is almost completely bare of soil, and the country is excessively bleak-looking. Between Kawa and Jacobs, however, a number of conspicuous gravel hills rise directly from this bare rock surface.

The precipitous topography characteristic of the Keweenawan sills is exemplified between Jacobs and Ogoki, where the railway skirts a small but rugged canyon carved in this formation.

391 m.
625·6 km. **Armstrong**—Altitude 1,113 ft. (339·4 m.). The Laurentian gneiss disappears under a mantle of boulder clay four miles (6·4 km.) east of Armstrong and, from this point to Lake Nipigon, solid rocks are infrequently exposed. Low sand hills and muskegs, intersected by sluggish creeks, take the place of the hummocky rock surface and rock-bound lakes. Near Wagaming the boulder clay merges into a comparatively flat plain underlain by the stratified sand and clay of glacial Lake Warren. There are few excavations along the railway in which these lacustrine deposits are favourably exposed, but natural sections are exposed by the streams flowing toward Lake Nipigon, which are rapidly deepening their channels

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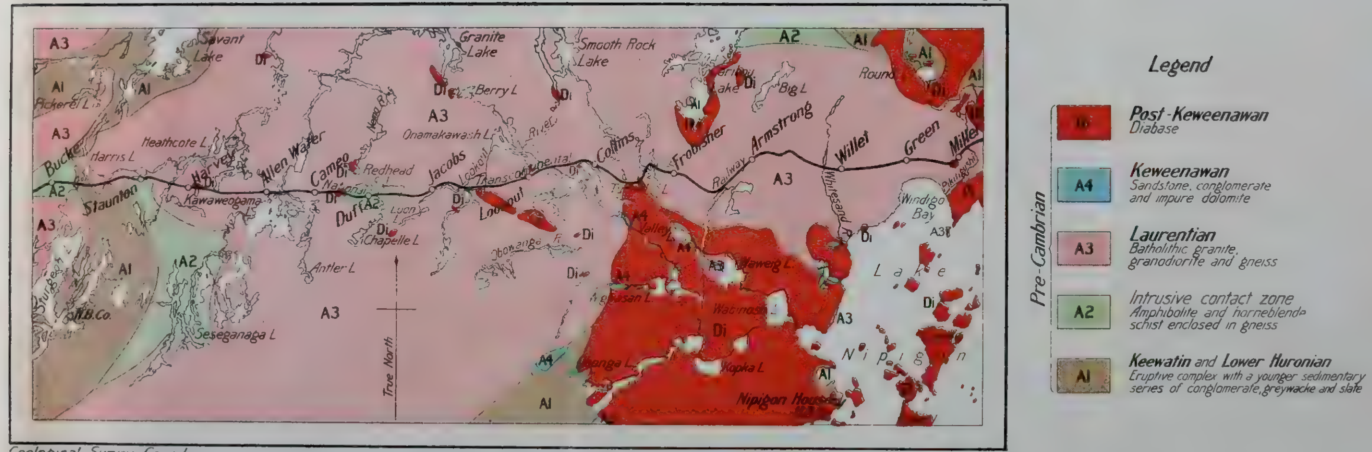

Geological Survey, Canada

Route map between Lake Nipigon and Bucke

Miles
10 0 10 20 30
Kilometres
10 0 10 20 30 40 50

Miles and Kilometres.

toward the underlying Pre-Cambrian rock surfaces. Just west of Willet, Mud river altitude 904 ft., (275·5 m.) has cut a channel 60 feet (17·8 m.) deep in stratified silt and clay. **[4].**

421 m. 673·6 km. **Ferland**—Altitude 970 ft. (295·8 m.) The only important rock exposure in this vicinity is a monadnock-like hill of Keweenawan diabase, known as Haystack mountain, which projects through the lacustrine deposits near Willet.

ANNOTATED GUIDE—(Continued.)

BY

A. G. Burrows.

Between Lake Nipigon and Iroquois Falls the underlying bed rock is largely covered by glacial and post-glacial deposits. The number of outcrops, however, have been considerably increased by excavations made during the construction of the railways.

The solid rocks outcropping between Lake Nipigon and Iroquois Falls consist chiefly of biotite and hornblende granite, granodiorite and diorite. These are all more or less foliated and frequently intruded by numerous dykes of pegmatite and aplite. They belong to the pre-Cambrian granite-diorite complex generally called Laurentian.

416 m. 660 km. "*Dist.E." 215 m. 346 km. **Pikitigushi river** — Altitude 898·4 ft. (272·4 m.). Two miles east of the crossing of Pikitigushi (Mud) river there is a N.-S. trending ridge of Keweenawan diabase which continues southward to form a very prominent peninsula on the north shore of Lake Nipigon, known as North Ombabika.

* The miles and kilometres given under districts refer to the distance from the easterly limit of the subdivisions into which the country along the National Transcontinental was divided for engineering purposes. Thus Cochrane lies 103 miles west of the eastern limit of District D.

Miles and Kilometres.

470·5 m. 762 km. "District E" 166·5 m. 267 km.

St. Lawrence—Hudson Bay divide. Altitude 1,122 ft. (341·9 m.). Forty miles (64 km.) to the east of Ombabika the railway crosses the height of land between Lake Superior and Hudson bay. The rivers to the east of this watershed all flow into the Albany and Moose, two large rivers, which have their outlet into James bay, the southern extremity of Hudson bay.

The bed rocks in the vicinity of the height of land belong to the Keewatin complex. The Pleistocene deposits are largely stratified sand, clays and gravel.

After crossing the height of land the railway enters upon the region underlain by the post-glacial lacustrine deposits of Lake Ojibway which is now generally known as the clay belt of northern Ontario and Quebec. There are many million acres of these lacustrine clays which afford an excellent soil for the growth of wheat and other cereals and a colonization movement to the region has begun. The provincial governments are assisting this movement by building numerous trunk roads to enable the settlers to gain access to their farms.

570·5 m. 925 km. "District E." 60·5 m. 97·3 km.

Pagwachuan river—Altitude 578 ft. (176 m.). West of the Pagwachuan river there are several outcrops of dark, banded, hornblende-biotite-gneiss containing phenocrysts of red feldspar up to two inches in length.

626 m. 1,023 km. "District E." 6 m. 10 km.

Kabinakagami river—Altitude 787·3 ft. (239·9 m.). The railway crosses Kabinakagami river at a rapid formed by a barrier of Laurentian gneiss. Similar gneiss can also be seen at the crossing of White, Skunk and Nagagami rivers.

643·5 m. 1,055 km. "District D." 232·5 m. 347 km.

Hearst—Altitude 795 ft. (242 m.). Hearst, situated two miles west of the crossing of Mattawishquia river, is a divisional point on the Transcontinental railway and the junction point with the Algoma Central railway. The town lies in the midst of a wide area of country possessing an excellent soil for the growth of agricultural products.

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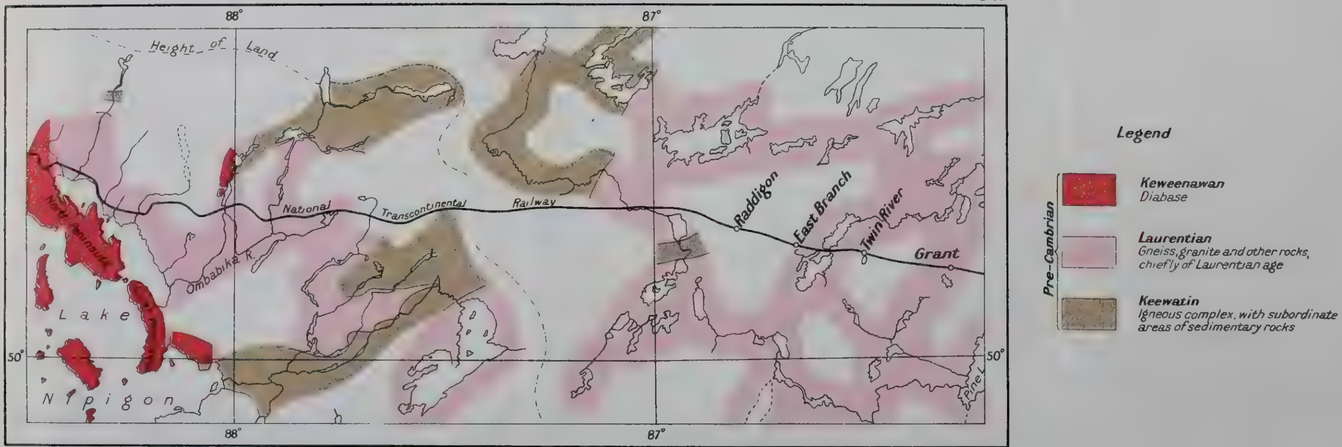

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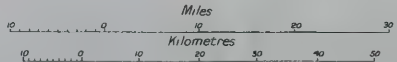
Route map between **Grant** and **Lake Nipigon**



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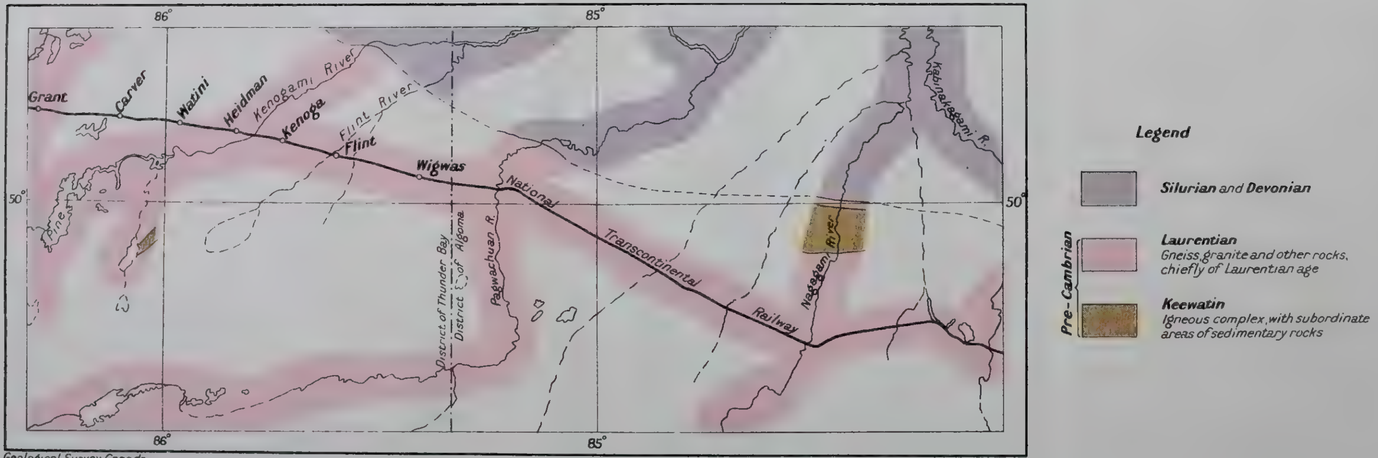


Geological Survey, Canada.

Route map between **Kabinakagami River** and **Grant**

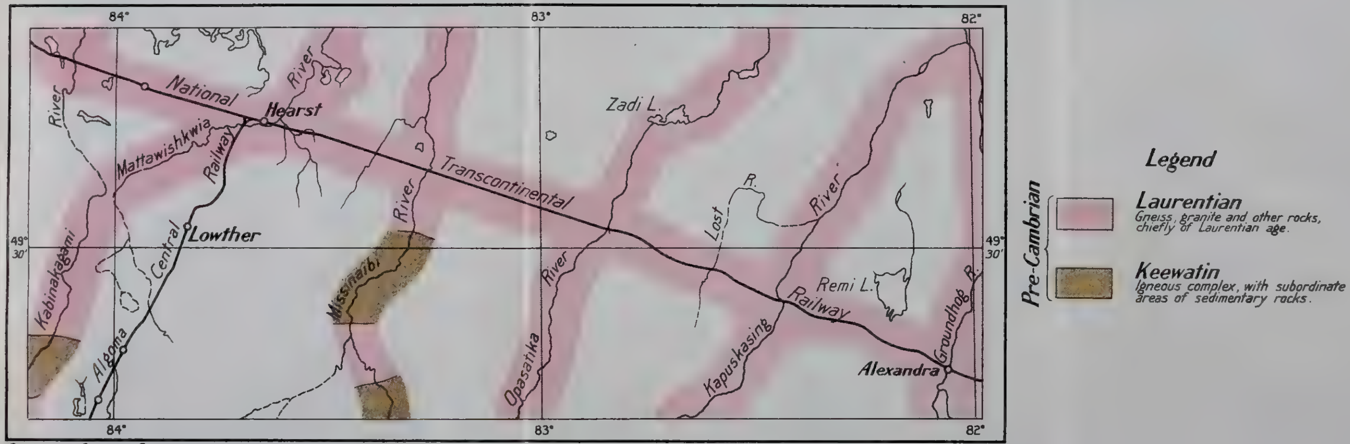
Miles

10 0 10 20 30

Kilometres

10 0 10 20 30 40 50

C4.



Geological Survey, Canada.

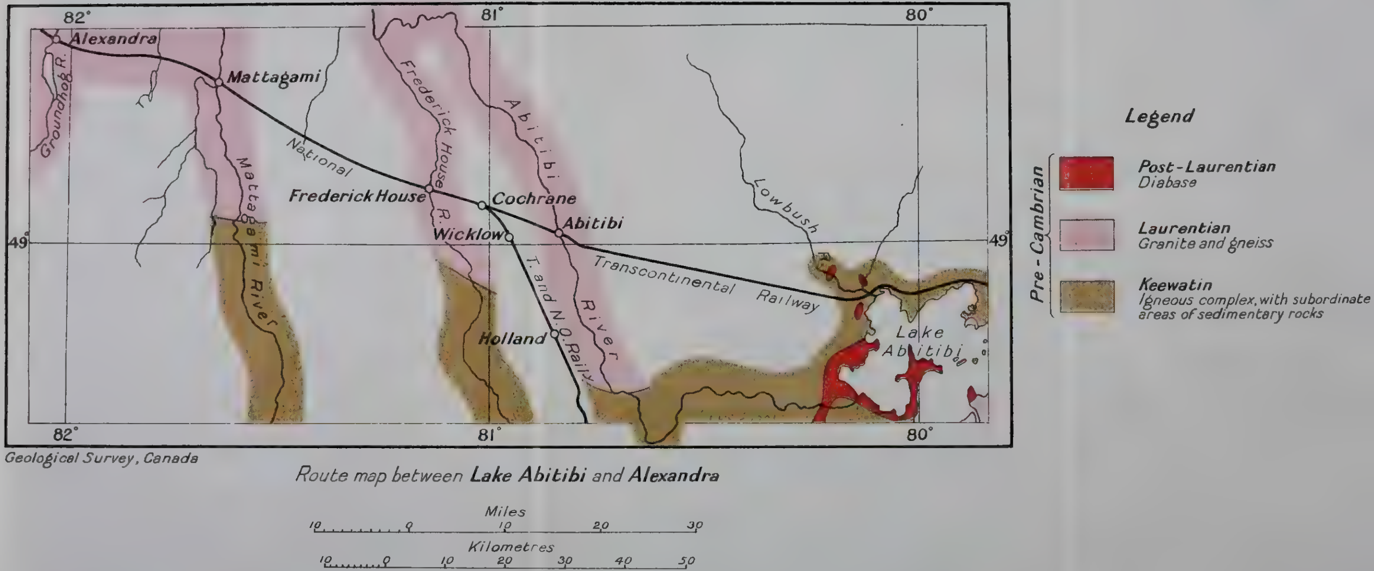
Route map between **Alexandra** and **Kabinakagami River**

Miles

10 0 10 20 30

Kilometres

10 0 10 20 30 40 50



Geological Survey, Canada

Route map between **Lake Abitibi** and **Alexandra**

Miles and Kilometres. Three miles (4·8 km.) west of Hearst, grey, biotite-gneiss cut by dykes of light coloured, biotite-muscovite-pegmatite is exposed in a rock cut along the railway. The foliation of the gneiss strikes N. 35° E. The rock surface has been greatly polished by the continental glaciers, the direction of the ice movement, as indicated by the striae, being S. 30° E.

The southern limit of the broad belt of Palæozoic sediments which lie to the south and west of Hudson bay, occurs just 15 miles (24·2 km.) north of this point.

662·5 m. **Missinaibi river.**—Laurentian gneiss is ex-
1,066 km. posed at the crossing of the Missinaibi, which is
"District one of the largest tributaries of Moose river and
D." for two centuries the principal route used by
213·5 m. the employees of the Hudson's Bay Company in
343 km. travelling from Lake Superior to Hudson Bay.

699 m. **Kapukasing river**—Kapukasing river is
1,125 km. crossed at a waterfall formed by a barrier of
"District mica-hornblende-gneiss which the river has
D." 173 m. encountered in cutting through the overlying
278 km. drift.

722 m. **Ground Hog river.**—Laurentian gneiss also
1,162 km. occurs at the crossing of Ground Hog river.
"District On the east side of this river the stratified clay
D." laid down in lake Ojibway can be seen in
153·5 m. section. Between Ground Hog and Mattagami
246·9 km. rivers there are several exposures of Laurentian
gneiss.

At mileage 730 (1,175 km.) a dyke of fresh diabase intrudes the Laurentian.

769 m. **Cochrane**—Altitude 915 ft. (278·6m.). Coch-
1,398 km. rane is the present terminus of the Timiskaming
"District and Northern Ontario railway and a divisional
D." point on the National Transcontinental. It is
103 m. also the centre of an agricultural district which
165 km. is being taken up rapidly by settlers.

The Pre-Cambrian bed rock is not exposed at Cochrane but glacial deposits and a number of clear water kettle lakes may be seen.

T. & N. O. railway. Miles from North Bay.

253·1 m. 407 km. **Cochrane**—Altitude 915 ft. (278·6 m.). From Cochrane southward as far as mileage 229 (368 km.) there is a rather flat area of country which is underlain by clay and sand covered with a layer of peat.

224·8 m. 362 km. **Iroquois Falls**—Altitude 945 ft. (288 m.). North of Iroquois Falls there are ridges of stratified sand and gravel with many clear water kettle lakes.

Iroquois Falls is the junction point of the main line of the Timiskaming and Northern Ontario railway and the Porcupine branch.

For a description of the route from Iroquois Falls to Porcupine and Toronto and the ore deposits of this region see guide to Excursion A3 in Guide Book No. 6.

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